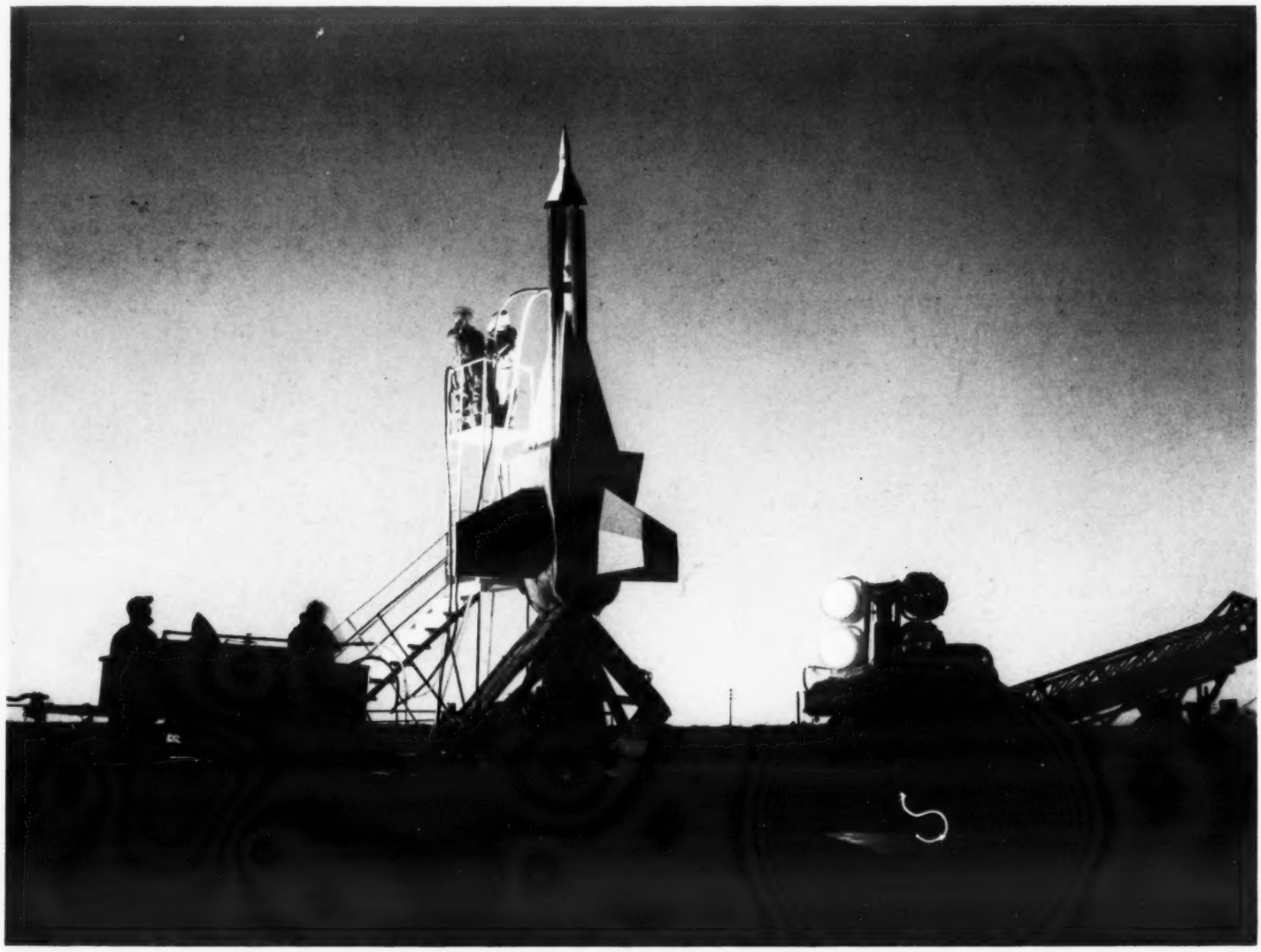
INTERAVIA

REVIEW OF WORLD AVIATION



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Flying Robots

VOLUME VIII 5 1953

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INTERAVIA

Review of World Aviation

Volume VIII — No 5 — 1953

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Front cover :

Before the break of dawn a crew of technicians prepares a Douglas multi-stage research rocket missile for firing. The two men on the platform wear special outer garments and helmets as a protection against the action of chemical fuel loaded immediately before the rocket is fired.

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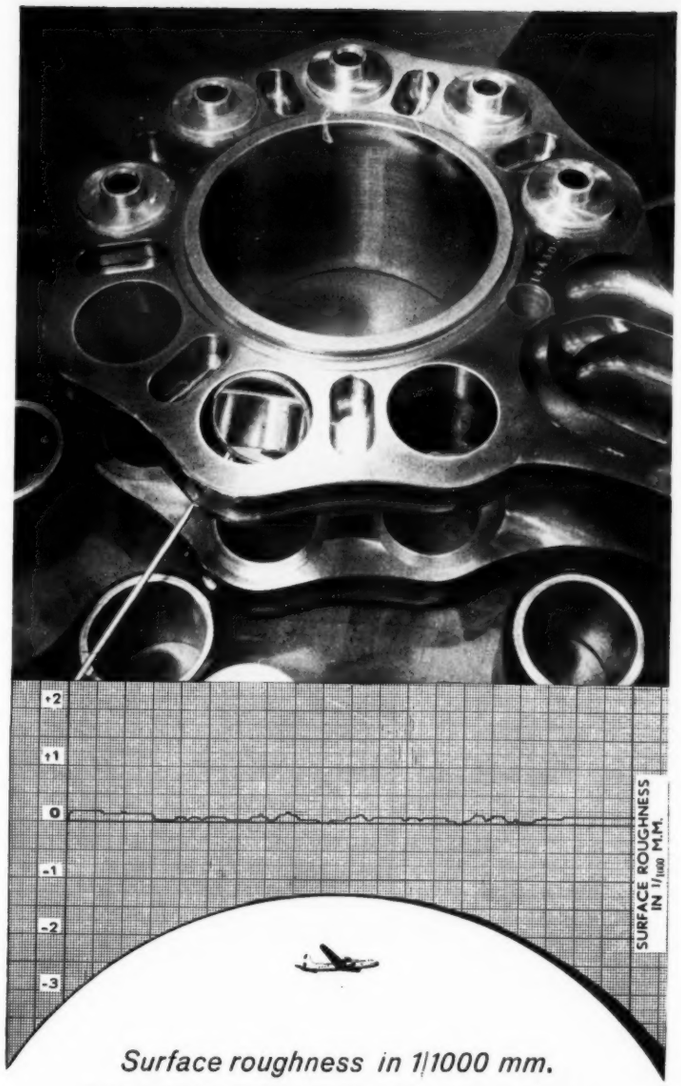

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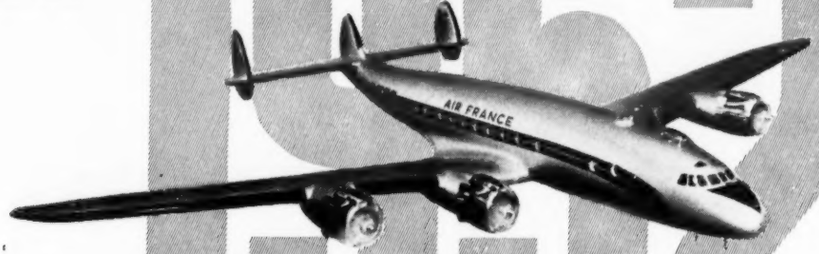

A constructive year, as the following facts show

The opening of several new routes brought Air France's network up to 250,000 kilometres.

APRIL :	Opening of the Paris-Mexico City service.
NOVEMBER :	Paris-Tokyo in 37 hours 30 minutes flying time by "Constellation".
DECEMBER :	Installation of sky lounge chairs on one of the Paris-Casablanca services. New luxury service to Dakar.
JANUARY 1953 :	Air France opened the Paris-Caracas-Bogota service.

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Air France is constantly improving and modernizing its fleet. During 1952, the famous Lockheed "Constellation", nicknamed the "Atlantic favourite", came into general use on the principal routes.

"Super Constellations", Vickers "Viscounts", de Havilland "Comets" and Bréguet "Deux-Ponts" have been ordered and will be put into service in 1953.

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On July 8th, 1952, Mr. Neeland, a representative of the U.S. Civil Aeronautics Administration handed over to Air France the certificate awarded by C.A.A. to the workshops of the Overhaul Centre and Maintenance Service at Orly Operational Centre. A similar certificate was awarded to the Courbevoie engine overhaul centre in October 1951. Air France is one of the few companies to hold this Civil Aeronautics Administration certificate.

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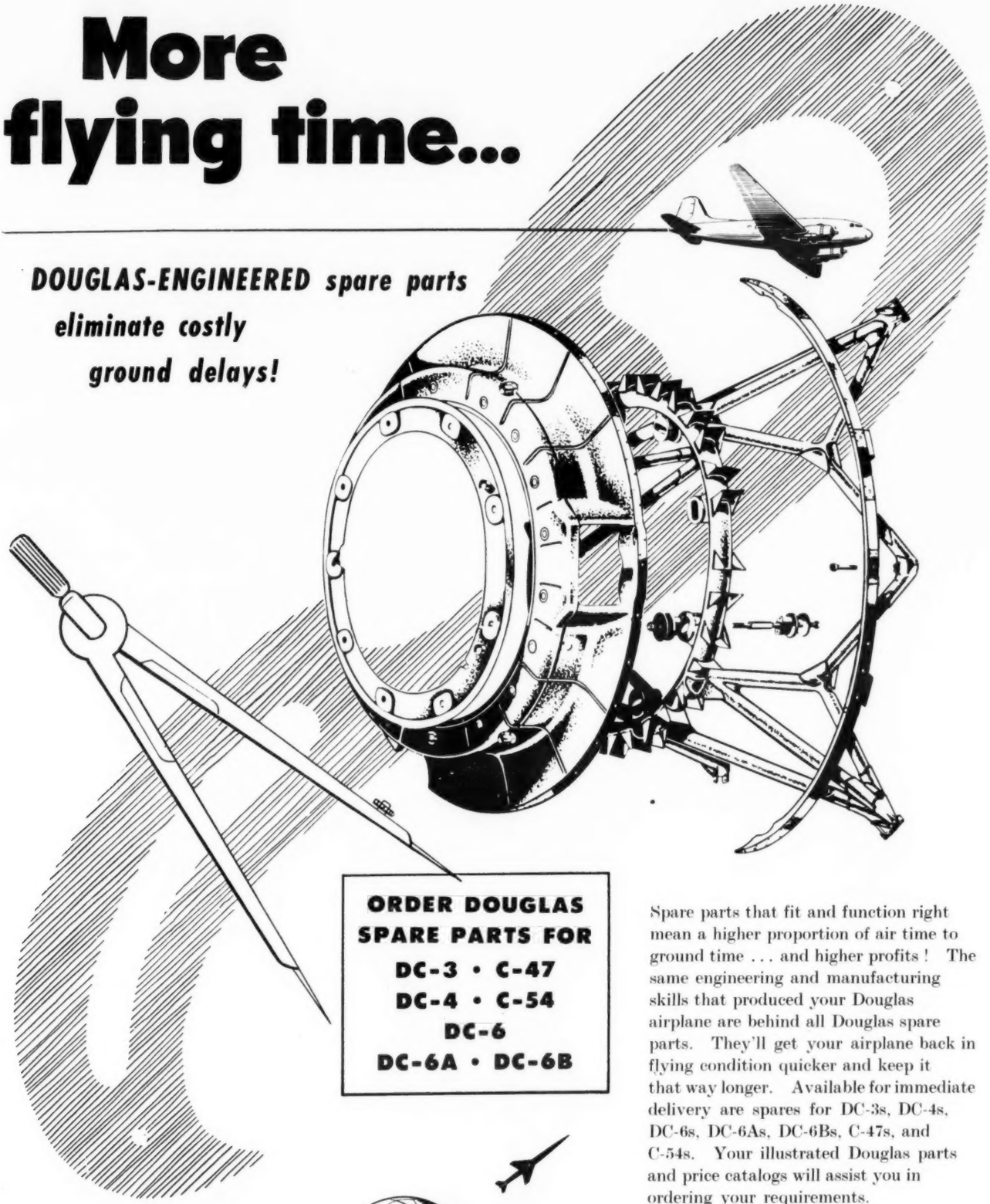

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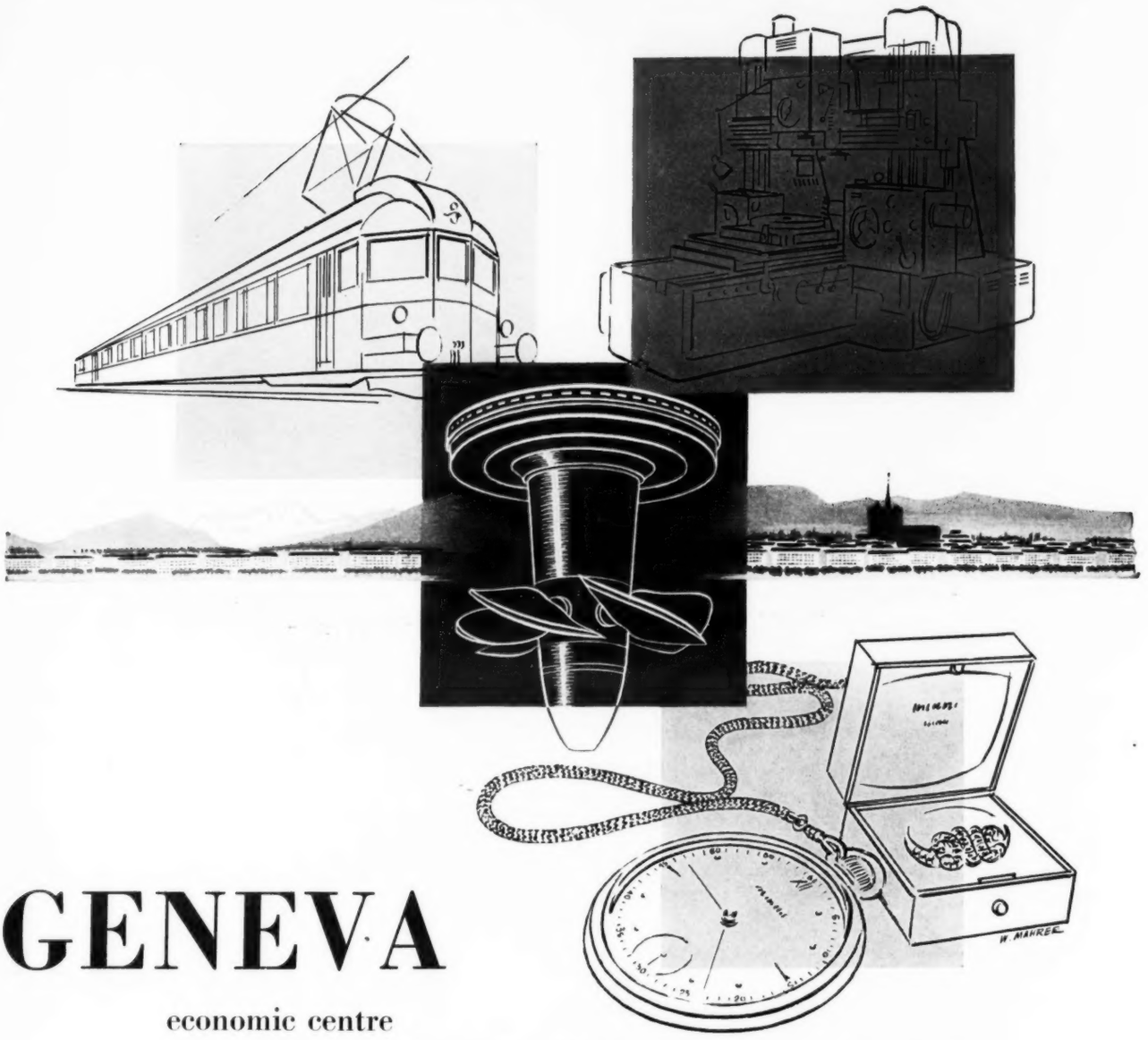

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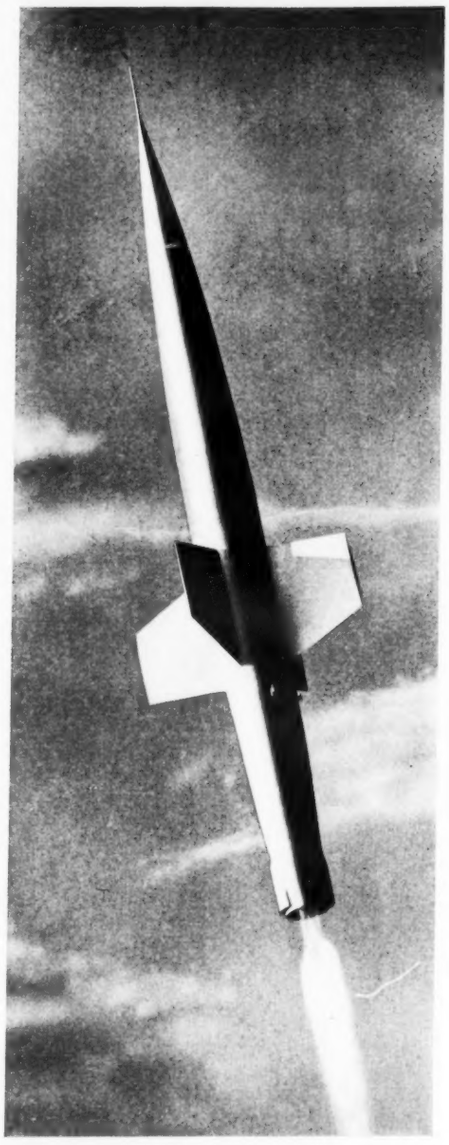
Oerlikon 8-cm powder rocket being fired from a Vampire fighter. Rockets are fired two by two by a launching apparatus at intervals of 0.1 seconds.



Oerlikon beam-riding liquid-fuel anit-aircraft rocket for use against high-speed targets at high altitudes.

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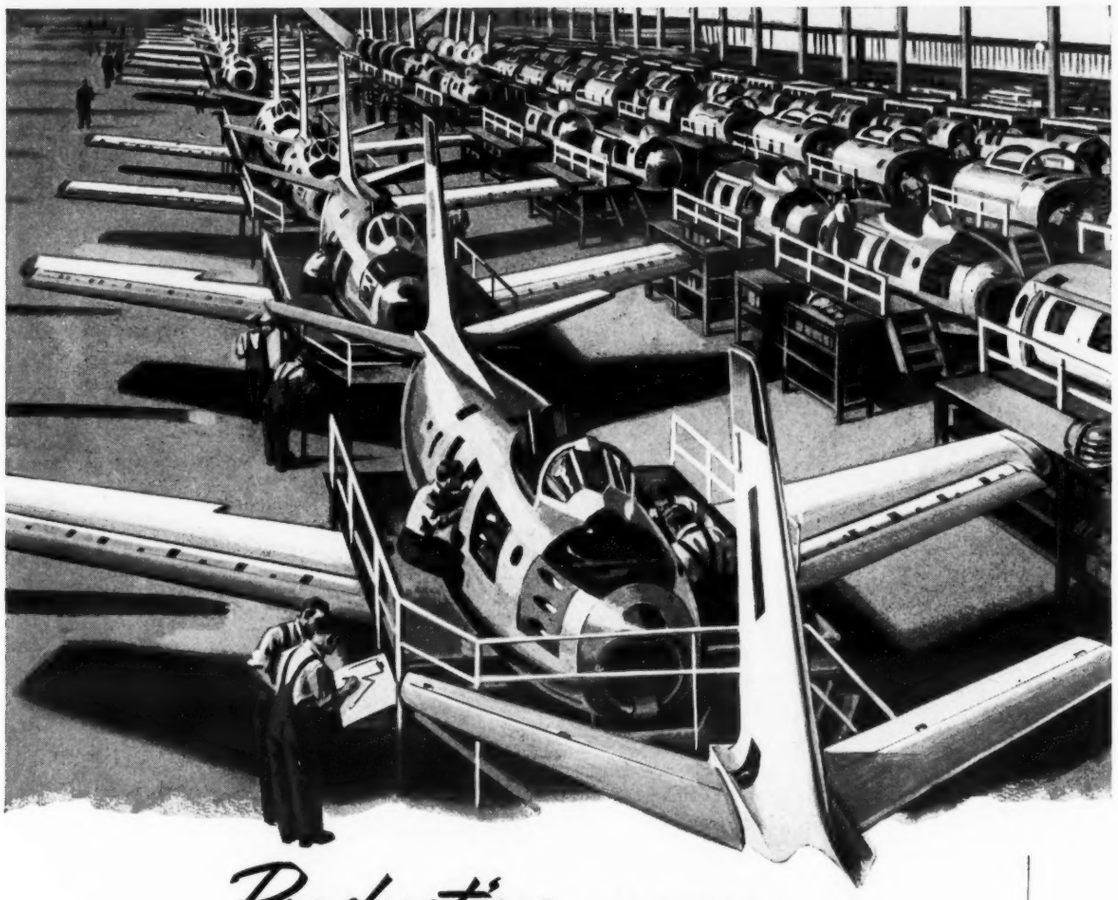

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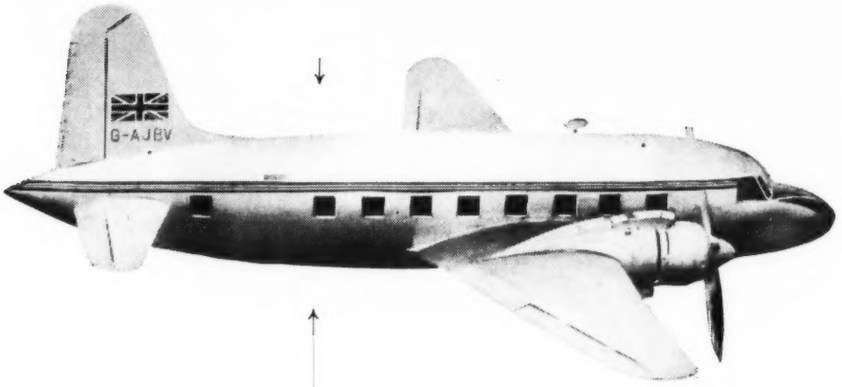
These aircraft are now OFFERED FOR SALE either singly or in fleet units, together with spares and ground equipment. Hire Purchase terms will be considered, also part purchase, part leasing arrangements.

The aircraft are the long-nose, metal-wing version of the Vickers Viking and, whilst at present equipped to carry 27 passengers, Aviation Servicing will undertake to carry out conversion if required, to increase the capacity to 36-38 persons.



Vickers Viking aircraft are of proven reliability and have been operating on the European routes with great success.

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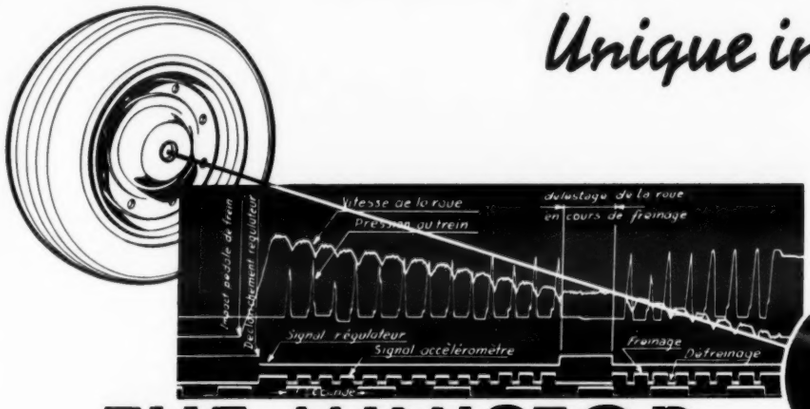
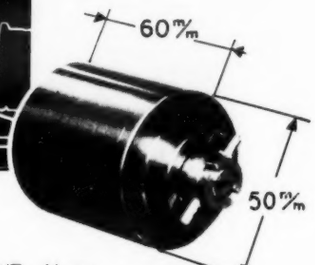


THE MINISTOP



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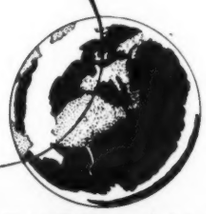

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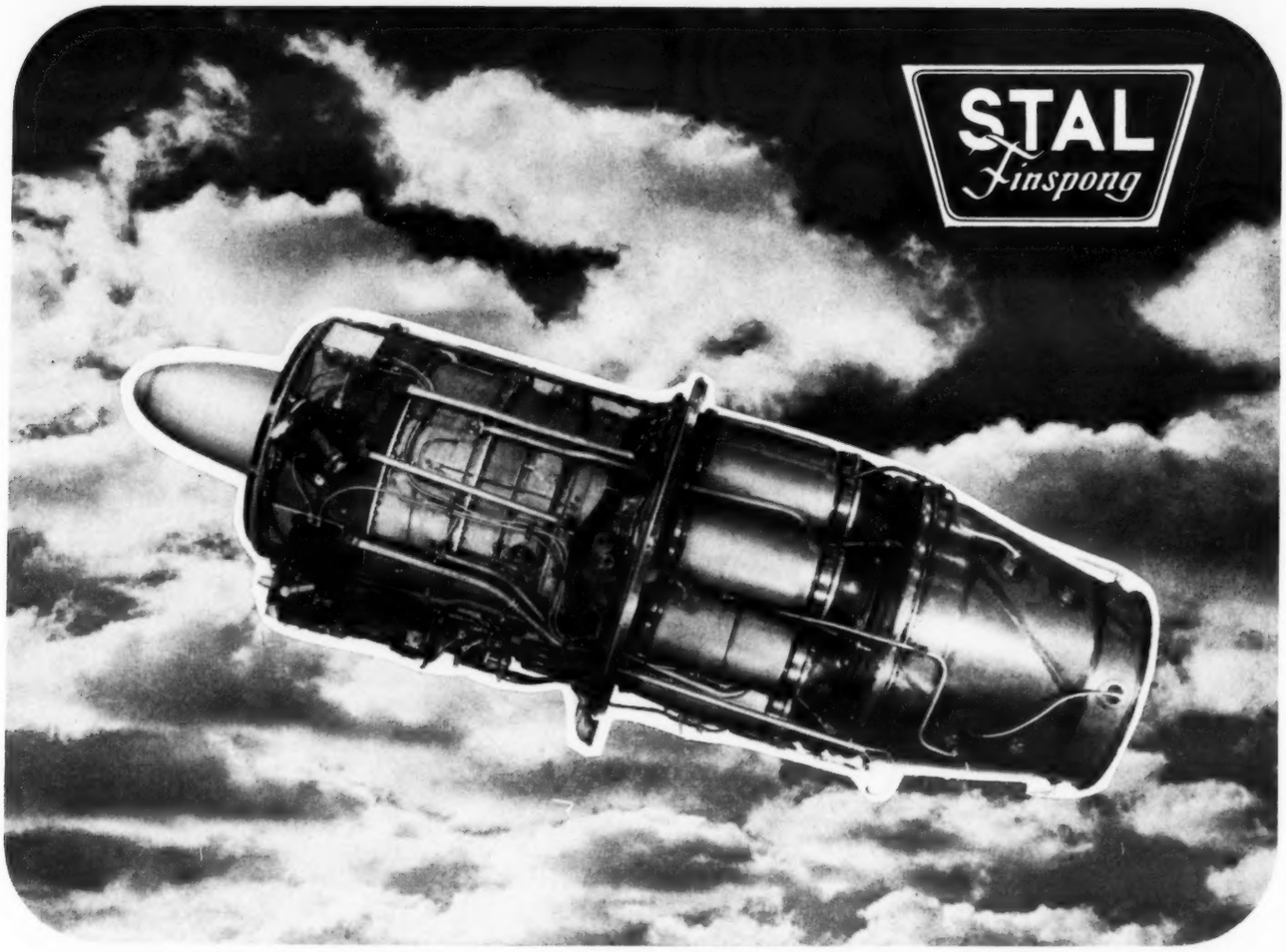

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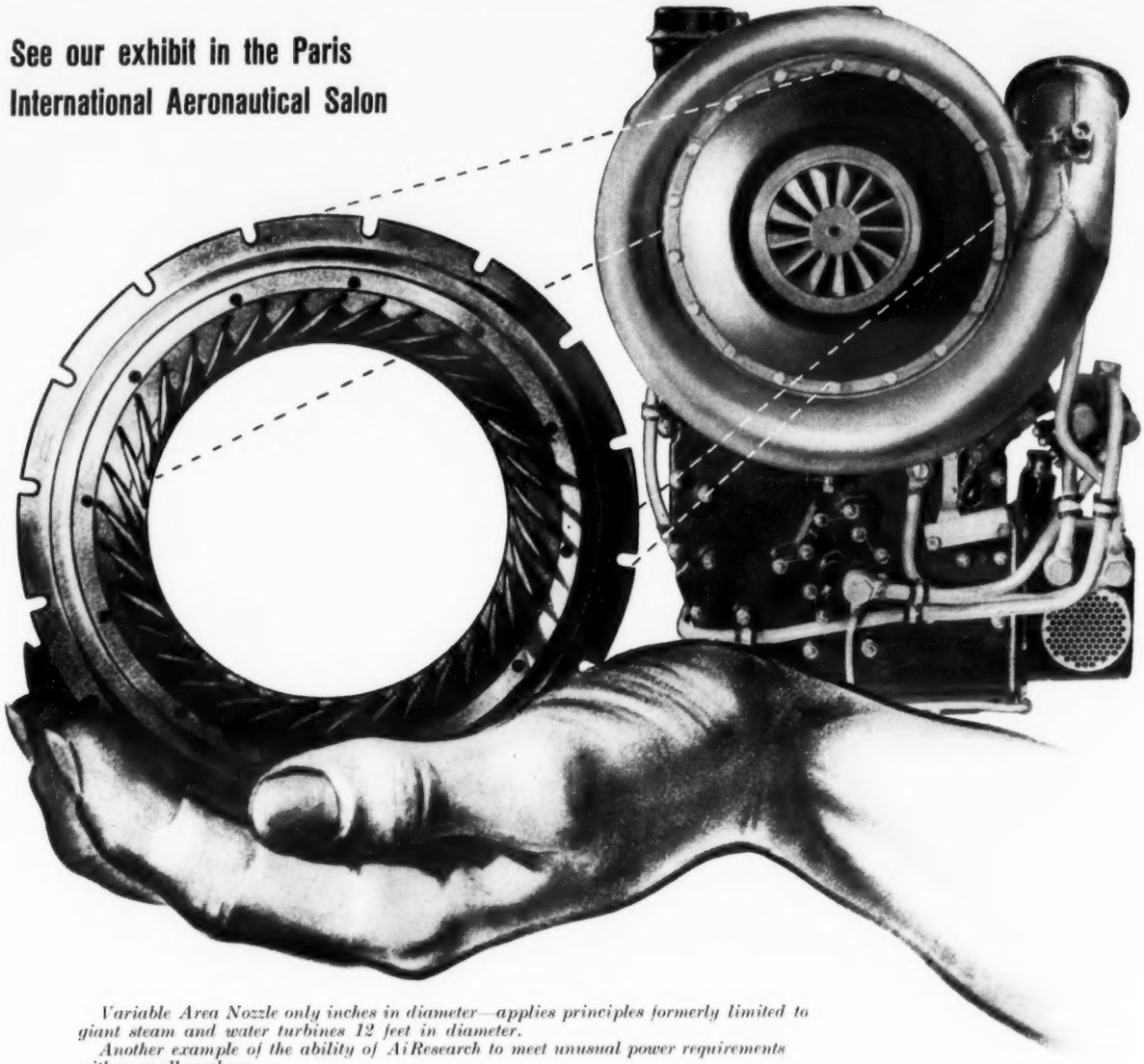

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** You will be welcome and will find much of interest in the field of aircraft accessories at our exhibit at the Paris International Aeronautic Salon.*

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"Fantastic Weapons"

The "fantastic new weapons" forecast by leading statesmen of the Western world are gradually becoming a reality. There has of course been talk of "wonder weapons" for nearly ten years, but the German unguided V1 and V2 and such experimental anti-aircraft rockets as the *Wasserfall, Schmetterling,* etc. were hasty developments, born of necessity, and were at best "wonderfully inaccurate." However, more recent progress in radio and control techniques has sufficed to develop these first forerunners of push-button warfare into useful combat weapons.

In the United States the first tactical long-range weapons developed for the Air Force and the Army (Martin B-61 *Matador* and General Electric *Hermes*) have recently been followed by a robot bomber for the Navy, the Chance Vought *Regulus*. Details of pilotless interceptors for the U.S. Air Force (Hughes F-98 *Falcon* and Boeing F-99 *Bowmark*) have also become known, and it has leaked through the veil surrounding the Americans' "cosmic secrets" that new guided missiles—*Omar-Sidewinder, Meteor* and *Petrel*—are under development (cf. *Newsweek*, March 9th, 1953). Today practically the whole of the American aircraft industry—Aerojet, Bell, Boeing, Chance Vought, Convair, Douglas, Fairchild, General Electric, Hughes, North American, Northrop, Martin, McDonnell, Ryan, etc.—together with a large number of accessories firms and the highly developed radio industry, is working on missiles of one kind or another.

On the other hand, information from Great Britain, France and Russia is still relatively scanty. Nevertheless it is known for certain that Bristol, de Havilland, English Electric, Faireys, Vickers, the Royal Aircraft Establishment and the Ministry of Supply on the one hand, and Société MATRA, Eca and SNCA du Sud-Est on the other have been working on guided missiles for some years. The Russians have reactivated the German research centre at Peenemünde, for example, and are apparently feverishly engaged in developing their German heritage.

In spite of the gaps in the material available today, INTERAVIA feels justified in giving readers a basic idea of a future development which must inevitably revolutionize the whole of military strategy and aeronautical engineering. A second guided missiles issue planned for the autumn of 1953 will be devoted to the technical side.

Robots Join the Arsenal

Air Arm and industry will use and make both piloted aircraft and guided missiles

BY LT.-COL. PIERRE M. GALLOIS, PARIS

Paris, 14th July, 19 . .
March-past on the Champs-Elysées

". . . Fully equipped, helmeted, wearing earphones, the Major commanding the unit stood erect in the front of a light cross-country vehicle. The staff followed in a group of liaison cars and two enormous trucks serving as mobile intelligence and operations rooms. The bulk of the troops passed by in field uniform, dressed in anti-radiation suits and mittens.

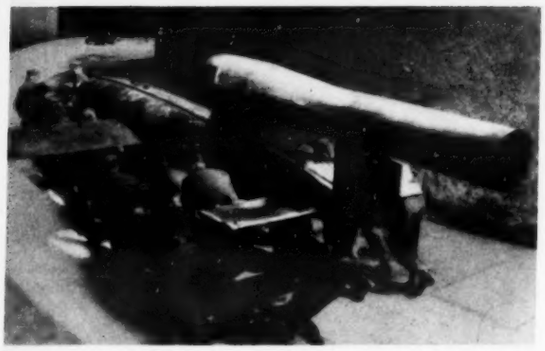
"Then came the missiles. They were carried on long trailers surmounted by a kind of truss forming launching rails or catapults. There were eight abreast and six in depth. The wings, delta-shaped, nearly touched, the fuselages, perfectly aligned, were inclined at an angle of at least 30 degrees, their slim noses pointing towards the sky. The speaker announced the electronic section of the unit, which rumbled by with its six antenna-bristling vehicles deployed across the street. Then came three trucks. Everybody knew that they were carrying equipment destined to assure the success of "counter-measures" for the local and temporary mastery of the ether.

"Mobile cranes for hoisting the guided missiles followed ; then came mobile workshops and trailers carrying propergols and kerosene. Twelve cross-country vehicles, each with four dismantled missiles, preceded ambulances, decontamination centres and fire fighting trucks. The train consisted of field kitchens and food supply trucks. With its 48 missiles, its 137 vehicles and its 654 men, Na/953 Light Tactical Missile Squadron stretched over nearly a mile.

"On several occasions the crowd had applauded, especially when fully assembled missiles passed by. But, with the announcement of the first public demonstration of an air defence unit, a prolonged murmur passed through the public, and all eyes turned towards the top of the avenue.

"This time, mobile radar stations led the procession. The announcer compared them to projectors with a light beam sufficiently slim to trace in space the trajectory likely to be followed by the missile.—He explained that this formed only a part of the fire control equipment, since the defence of vital points was supplemented by stationary installations.

"Weapon without soul" : Protected by concrete walls several feet thick, the firing engineer observes his guided rockets through an observation slit.



1944 : First use of long range missiles in the form of the German V1. This was an "aerial torpedo" powered by a pulse-jet and carrying a warhead of nearly 1,900 lbs.

Then, to the surprise of everybody, came a formidable display of steel tube scaffolding, the bizarre architecture of which reached more than 70 feet into the sky. Pipes and cables rose to platforms and cross bars, resembling the gear of a gymnasium. The whole thing might also have been a demolition team for skyscrapers. On foot, in ranks 24 abreast, the men handling this astounding equipment marched past.

"After another interval, the missiles rolled into view. Caterpillar-track vehicles resembling the little trucks that pull baggage carts along the railway platforms towed them. Lying horizontally, the long slim bodies were held by three powerful springs in the centre of solid metal rings mounted on rollers. In this manner the delicate mechanisms which stabilize the missile on its trajectory and guide its maneuvres were protected from the shocks and vibrations of the vehicle.

"A missile supply unit and a mobile depot, with forty trucks carrying missile bodies, twelve fuel cisterns and its curious propergols tanks had joined the Na/101 VAADO (Vital Areas, Air Defence Of) Squadron, the stationary elements of which could not be demonstrated to the Paris crowds.

"At the end of the march-past, three pilotless reconnaissance missiles, radio-guided from a command post installed on the *Arc de Triomphe*, roared down the Avenue like a whirlwind. They were 'intelligence' missiles equipped to photograph and televise images of the country over which they were flying. The speaker announced that television screens in the official enclosure were showing the pictures taken by the missiles at the same instant and that, after having seen the magnificent march-past from ground level like everybody else, the President of the Republic and his guests now had the privilege of seeing it again from above. But the 'intelligence' missiles were already circling above the *Louvre* prior to returning to their base, where an earth-bound pilot was getting ready to control their landings by radio . . ."

Looking into the future ? Certainly. Nevertheless, the description is hardly an imaginary one, since the majority of the elements constituting the guided missile arm are now in existence and several of them have passed from the experimental firing range to the munitions depots of regular service units.

Since combat aircraft have now all reached identical speed ranges and since, in consequence, the defensive fighter's chances of success have become feeble, air-to-air and even air-to-ground missiles have gained in importance. Since the treble combination of range, speed and power of destruction (A-power) is now in course of realization, thanks to the coming into service of bombers like the Boeing B-47, the missile designed to destroy aircraft in flight must be given absolute priority. Furthermore, since ground fighting now presupposes permanent aerial support, it is again the guided missile which is to be enlisted for the purpose. Finally, the theory that the machine should be substituted for the human element also militates in favour of the general adoption of missiles.

For many years, piloted aircraft and remote-controlled missiles will continue to exist side-by-side. Projectiles with atomic warheads will continue to be carried by piloted aircraft, because of their destructive effect and high cost, and reliance will continue to be placed on the judgment of human beings rather than on the most refined remote control mechanism. Piloted fighter aircraft, with their high potential concentration resulting from their man-directed mobility, offer sufficient advantages to assure their use to the limit of their efficiency. Furthermore, while destruction in flight can be facilitated by quicker identification of the enemy's aerial targets ; while the all-weather interceptor is brought into use in quantity and improved in quality, one will always resort to human judgment for the selection of mobile surface targets since the all-weather tactical fighter continues to await its equipment from the laboratories. Finally, intercontinental air missions, although attractive solutions have been found for them in the form of celestial navigation, still belong to the domain of human crews. Thus, technical possibilities, operational requirements and limitations define the limits within which the guided missile will predominate.

This evolution of the means of destruction in flight and on the ground will entail a corresponding modification of the organization and the composition of the air arm and also determine the shape of a new structure of the aerial armament industry. There will be a growing distinction between the design and production of carrying equipment and the development and manufacture of means of aerial combat. It is likely that the two sectors of what once was a single industry will pursue different courses which occasionally may meet, but in most cases will remain wide apart.

The aircraft becomes a missile

If the Martin B-61 *Matador* remote-controlled bomber for the destruction of surface targets has justified the formation of the first tactical guided missile unit, this is because the aims set by the creators of the *Matador* were very modest. The real significance of guided missiles no doubt lies in the field of anti-aircraft defence, in the attack on enemy bombers. The experts of the *Lincoln Project* study group fully confirmed the prediction by the American General Staff that at the present stage of development of the anti-aircraft defences less than 30 per cent of enemy aircraft could be eliminated before reaching American cities. In the course of its investigations, this study group even seems to have come to the conclusion that the estimated rate of destruction of 30 per cent was optimistic. A fighter of current types does not seem to have much chance of engaging a modern bomber in aerial combat, for the simple reason that it will not be able to catch up with it. Although the superiority of the bomber was less marked at the time, the Germans discovered this truth as long ago as 1943.

The first practical postwar measure to remedy the situation consisted of the modification of the fighter's armament, namely, the change-over to rockets. The task of the aircraft designer has certainly been made easier by the advent of the rocket. Since it works

1953 : A vast guided missile industry has come into being, chiefly in the U.S. Picture shows a rocket engine developed at the Aerophysics Laboratory of North American Aviation Inc., being tested on a motor static test bed at the company's Santa Susana Field Laboratory, near Los Angeles.

Arming jet fighters with unguided rockets is merely an interim solution. Here a North American F-86D *Sabre* fires 24 2.75-inch *Mighty Mouse* rockets.

without recoil, lighter aircraft structures are permissible. As far as the pilot is concerned, he can open fire from greater distances with projectiles of greater power and no greater degree of dispersion than conventional shells. He therefore has the advantage over the defensive gunner of the bomber. However, the combination of the piloted fighter plus rockets also has a disadvantage ; while it increases the firing distance from 1,500 to 6,000 feet, it correspondingly reduces the chances of a direct hit.

The light piloted fighter, armed with rockets, can reach its operating altitude and take up firing position in a shorter period of time. However, it brings us to the conception of the "air defence weapons system," for its activity is unthinkable without a complete approach-warning and fighter control system and the ground installation it requires, in spite of its light construction, to return safely to base. Its air-borne radar will constitute a relay station between the ground radar and the enemy aircraft.

Owing to its small size, the stripped piloted fighter is relatively less vulnerable and cheaper in manufacture. Consuming vast quantities of fuel, it will return to base with its tanks virtually empty and lightened by its 1,500 to 1,750-lbs. rockets load. Thus, landing will be relatively easy. Work on stripped fighters is going on in nearly every country, and it is realized today that such types should have been designed several years ago.

*

Hughes, with the F-98 *Falcon,* and Boeing, with the F-99 *Bowmark* have attempted to go one better. Both have endeavoured to replace the pilot by a system of electronic instruments. *Falcon* and *Bowmark* are destined to play the role of flying relay stations, carrying rockets. Their air-borne radar guides them to the vicinity of the enemy, takes over fire control and then returns the flying control to the ground radar station which guides the aircraft to base. The advantage of the formula is that the human crew stays on the ground. The disadvantages lie in its vulnerability to jamming measures by the enemy and in the impossibility of reacting promptly against a sudden saturation of the defences by the attackers. Though attractive at first glance, this type of weapon will still require very thorough study before the whole of air defence can be entrusted to it.

Automatic weapons are now encountering a competitor which significantly is again a piloted aircraft but which is a guided missile carrier rather than a mere rocket launcher. The aircraft becomes a kind of firing platform, racing towards the enemy at high speed. From variable distances, it launches its guided missiles, the target-seeking control heads of which immediately begin to track the assailant. The piloted fighter thereupon returns to base to fetch another load of missiles for a second ascent towards the crossroads of aerial combat. This again is only a partial solution of the problem, permitting the interdiction of a certain sector of air space to the enemy. The ground control station guides the aircraft to the assailant, but it is up to the target-seeking heads to close the cycle by directing the missiles towards the enemy. Yet another step towards fully automatic air defence is conceivable : guided by radar to the vicinity of the enemy, the piloted fighter would maneuvre into attacking position by means of its air-borne radar, so as to facilitate the task of the target-seeking heads of its guided missiles. While this method would expose the fighter to the enemy's defensive fire for a longer period, the work of the guided missiles would be much less complex. Both solutions have advantages and disadvantages.

The second entails greater vulnerability of the fighting equipment, without making full use of the automatic navigation capabilities of guided missiles. The first seems paradoxical because it requires the installation of complicated and costly navigation instruments in the expendable guided missile, instead of leaving this equipment aboard the piloted fighter returning to base. It is obvious that both methods are interim solutions with some common features :

— First, the conventional role of man is unchanged, in that he is not and cannot be left on the ground. All the same, this type of fighter is a preliminary version of the guided missile, a firing platform which has to be brought back to base with its pilot and the complex, costly equipment (in the first of the two solutions mentioned above).

— Second, both methods presuppose the coexistence of three defensive weapons : anti-aircraft artillery (on the lines of the Skysweeper) ; conventional fighters carrying guided missiles. According to the requirements of each theatre of war, each one of these weapons will be given its particular task. However, they can complement themselves and, suitably integrated, might form that defensive barrage in width and depth which the experts of the *Lincoln Project* had envisaged.

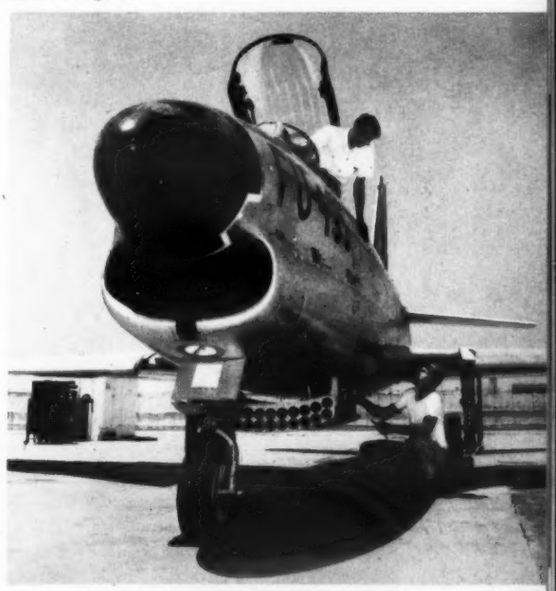
These interim solutions are likely to have their effects on the organization of the fighting forces and the development and production of new equipment.

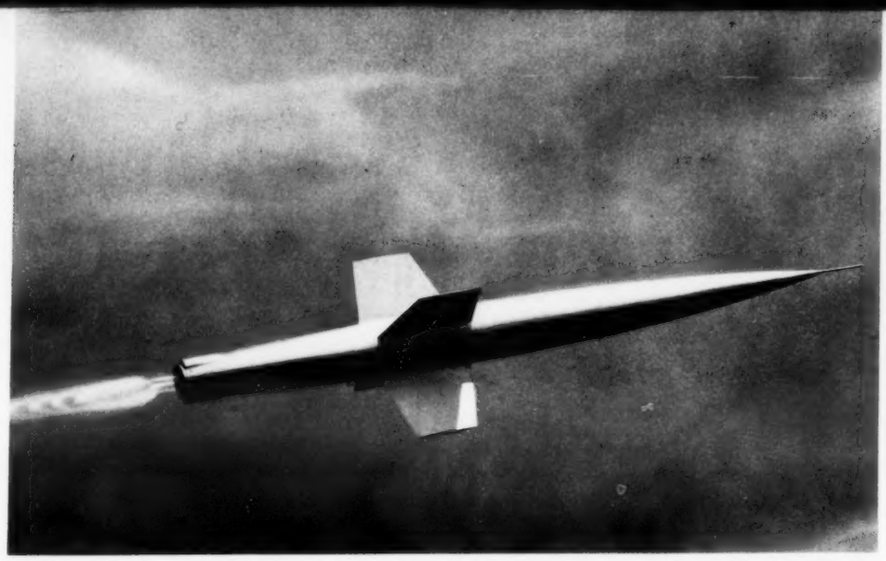
The relatively new conception of an "air defence weapons system" is assuming a continuously more precise form. None of the new weapons is thinkable without the creation of a complete supporting apparatus, such as early warning and fighter control by ground radar, counter-measures to eliminate enemy interference, recovery and re-armament of the fighter. Tied by its short range to the target it must defend, the missile-carrying fighter must rely on a novel kind of ground organization (launching ramps or catapults, arrester gear for landings in small areas, mobile cranes and other spezialized equipment for handling on the ground). In addition to these special installations, the conventional ground organization must continue to be available. Furthermore, it will be the duty of the design engineers to develop the aircraft "around" the guided missiles it will carry and to adapt its performance to those which the scientists are imparting to the "electronic brain" of the missile. In other words, a new field of activity is opened up to the military and engineers, in spite of the fact that at this stage conventional methods cannot be eliminated entirely.

*

The second stage, that of the "integrally guided" anti-aircraft missile, is now appearing on the horizon. It is still in the far distance because it assumes the solution of numerous, extremely complex preliminary problems. To traverse the denser layers of the atmosphere,

The retractable rocket tray of the F-86D *Sabre* all-weather fighter. The 2.75-inch rockets are designated FFAR (Folding Fin Aircraft Rocket). The aircraft carries no guns.





An "integral" solution for short-range air defence is provided by the anti-aircraft rocket. A beam-riding Oerlikon rocket in flight.

the guided missile requires propellants (liquid fuel-rocket) which are as voluminous as they are heavy. Light-weight guided missiles are not yet practicable (the German *Wasserfall* anti-aircraft rocket weighed more than three tons). Pictures published by the American Press of one of the most successful new ground-air guided missiles show a projectile of very large dimensions, particularly for the first phase of the trajectory, because multi-stage weapons (involving at least a booster rocket) are required.

At a manufacturing cost of about $30,000 per ton, the total price of the weapon would probably reach $100,000—a lot of money for expendable equipment. Despite the decisive defensive tasks assigned to this weapon, its cost would be out of proportion to the potential results. But there are other considerations, for example the short ranges and the demand for ground organization, which initially will limit such missiles to the role of supporting weapons. Assuming a range of about 20 miles, they would embrace only about one-sixth of the effective range of modern radar equipment. While it is certain that the fully automatic guided missiles one day will replace today's interim solution, much time will pass before that point is reached. In the meantime, guided missiles and greatly advanced developments of conventional fighters will exist side by side and complete each other.

The artillery is eyeing the guided missile

However revolutionary the *Matador* may seem as the pilotless aircraft of an experimental Squadron of the USAF, it hardly differs in aspect from conventional aircraft. It has a swept wing, a high-set elevator unit and a pointed nose on which only the pilot's canopy is missing. No wonder that the personnel and equipment of a B-61 *Matador* Squadron will have no "flying" pilots, that the maintenance personnel will be less numerous and that more drivers and a larger fleet of trucks will be required—since the guided weapon itself will remain immobile until it sets out on its first and only mission.

These missions must be confined to stationary targets of relatively large dimensions if the warhead of the *Matador* carries TNT. If it has an atomic warhead, the B-61 will be able to attack any decisive target, irrespective of size.

Compared with a squadron of F-84 *Thunderjet* fighter-bombers, the *Matador* unit has two advantages : It is independent of the prevailing weather and can dispense with the gigantic ground organization upon which flesh-and-blood pilots must rely. It is therefore extremely mobile, hardly vulnerable and relatively independent of terrain features of the operational area. On the other hand, a formation of pilotless aircraft has the following drawbacks :

— It must always cooperate closely with a reconnaissance unit, since it is practically "blind." In attacks on mobile targets, it cannot dispense with observation aircraft any more than artillery. Sooner or later, "spectator" reconnaissance squadrons may be added to the *Matador* units in order to enable the *Matador* firing crews to "see" by means of television equipment.

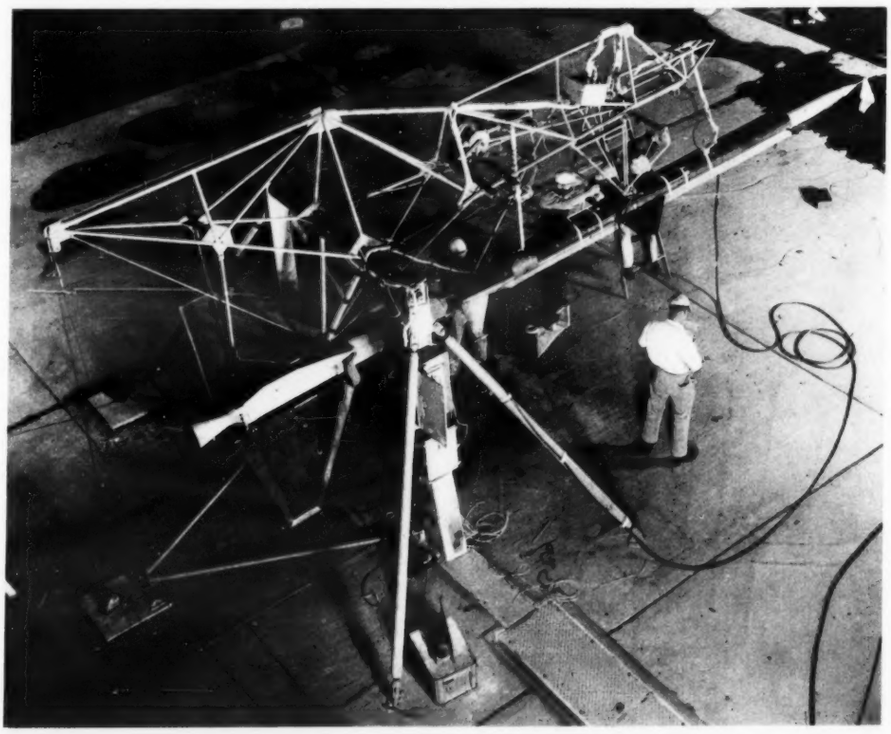
— In place of the redundant maintenance set-up, the *Matador* unit needs an enormous logistic organization. In this respect, it resembles an artillery unit, using shells weighing six or seven tons. Since these projectiles will travel at about the speed of sound, their production will be very costly. Whether expendable or not, high power engines require a great amount of labour.

— Lastly, the range of the B-61 still leaves much to be desired, and its accuracy is probably inversely proportional to the distance of the target.

These disadvantages are not decisive. An all-weather missile, the *Matador* can use its speed to pierce any defences currently in existence. Fitted with an atomic warhead, it can do crippling damage to a stationary enemy installation.

The question which remains to be answered is this : which of the Services is to be entrusted with the operation of guided missiles ? The elimination of air crews would seem to place

In order to attain sufficient initial acceleration, the anti-aircraft rocket requires either a catapult or a booster rocket. Above is Boeing experimental rocket (GAPA) with a large solid fuel booster ; the launching ramp is movable.



these weapons in the category of artillery. Since, however, guided missiles are descended in a direct line from the aircraft and continue to "manoeuvre" in the air space, the Air Force will be loath to relinquish its control over them. A British writer quite shrewdly suggested recently that, in conjunction with the adoption of guided missiles on the broadest basis, today's individual Services should be abolished altogether and replaced by a unified "Defence Service" which would use the individual types of guided missiles for their particular purposes. We have not reached that point yet, and it seems likely that the question will be settled differently by the prolonged co-existence of certain conventional types of armament and the novel missiles, inasmuch as each Service will add to its present organization those missiles units which correspond to its own particular duties.

The global weapon

Interception by guided missiles is the trump card of modern anti-aircraft defence, and it remains to be seen whether it will be effective against the atom-bomb-carrying aircraft. Tomorrow, the guided missile may not only provoke another shift in the equilibrium between attack and defence, but it may also become *the* weapon deciding the issue of a world conflict—no more, no less. Whereas the engineers are seeking a riposte to immediate threats, the really vital race for the world lead in the development and use of the future space weapon is now taking place in the laboratories and at the computing machines.

The race of the most destructive explosive has now obviously entered on its decisive phase. Both sides in the cold war have in stock undisclosed quantities of strategic and tactical A and H bombs. The threat of the West's B-36 and B-52 "global" bombers will no doubt be answered in the East with new four- or six-engined long-range bombers. Unanswered is the question as to which party will be the first to possess a carrying vehicle as superior to current equipment as the atomic warhead is to chemical explosives. Logically, this vehicle will be a development of the V2 applied on a global scale. However, colossal as the task may seem, the difference between the V2 of 1944 and the Vx space weapon of tomorrow will no doubt be smaller than that between chemical and atomic explosives. It is certain that the solutions to many questions still have to be found: the elimination of the detrimental effects of heat caused by friction, the development of prime movers ten times as powerful as those experimentally available today, the co-ordination of ballistics and navigational requirements . . . Millions of man hours and billions of dollars will have yet to be spent on the development and production of the first global weapon.

However, the decision at stake is so important that even seemingly insurmountable obstacles will not cause the work to be abandoned. But its completion may require decades.

More surface transport instead of "supermen"

The guided missile has ushered in a new era of military operations, science, research and industrial production :

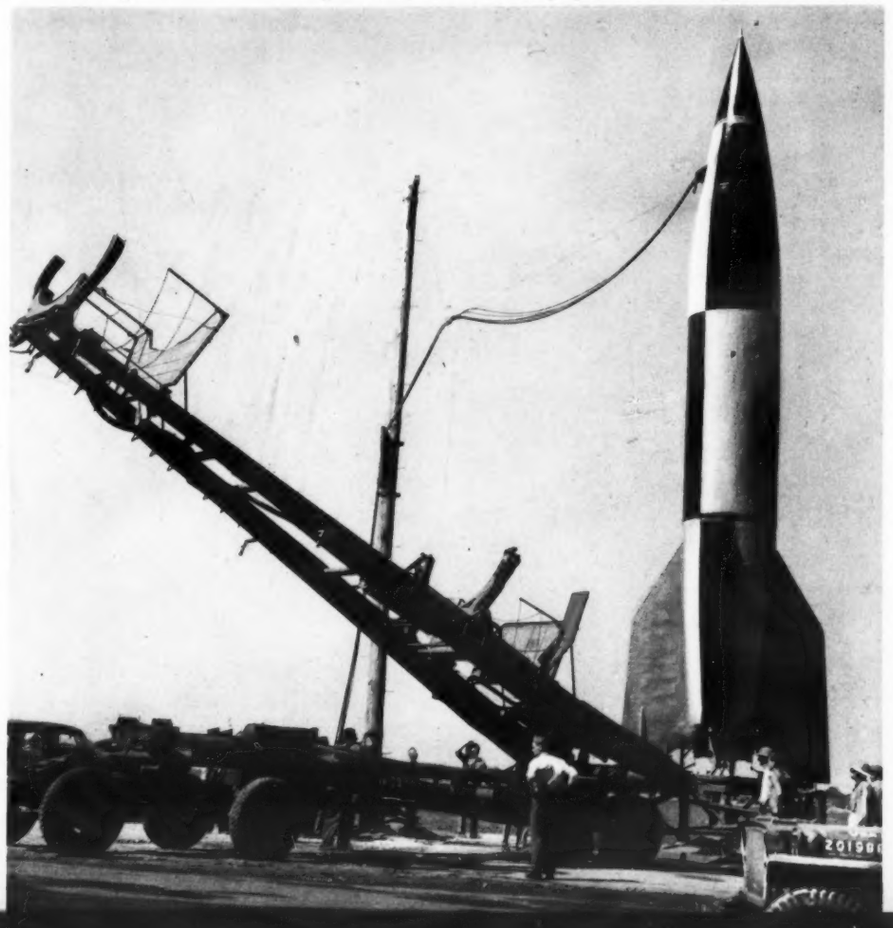
1. The users of guided missiles, chiefly the air forces and the naval air services, have an opportunity of fully appreciating the significance of the elimination of air crews. Recruiting and training, medical care, administrative questions of all sorts, the coordination of man and machine and many other problems will be solved much more easily. Were it not for the necessary co-existence of the two types of equipment, the personnel structure of the air arm would change fundamentally overnight. This is important, for 20 to 25 percent of all air appropriations are allocated for training at the present time.

2. Substantial changes will occur in operational routines with guided missiles, repair and overhaul will be limited to the supporting equipment. For the weapon itself, the munitions depot takes the place of the repair shop. The supply services will become anything but simpler, since the transport and assembly of the guided missiles will constitute an important factor, requiring considerable engineering resources. On the other hand, the removal toward the rear of equipment in need of repair no longer exists, and industry can concentrate fully on production without having to worry about maintenance and overhaul. As regards the Services, they will not be able to make any substantial economies. It is estimated that they will be able to save about 15 percent of the manpower strength as a result of the elimination of maintenance requirements. On the other hand, the transport facilities at their disposal must be vastly increased.

3. In the operation of anti-aircraft missiles, as well as missiles used against ground objectives, the development of "counter-measures" is indispensable. The "engagement" of the missiles will be preceded by a fight—either protracted or sudden and brief—aiming at securing local mastery of the radio waves.

A guided B-61 *Matador* bomber of the first guided missile unit of the USAF, established in 1951, ready for firing on its cross-country launching trailer. At take-off and during the initial climbing phase the gas turbine engine of the B-61 is assisted by a powder rocket. It drops off when its fuel is spent.

Will the development of intercontinental guided missiles lead to rocket-propelled atom bombs patterned on the V2?



Aircraft and Tactical Missiles? — A Comparison

	Fighter Bomber Unit 25 aircraft	*Tactical Missile Unit (Matador Type)* 48 missiles
Instantaneous fire power	25×20×10 lbs. = 5,000 lbs.	6×1,650 lbs. explosive fired simultaneously = 9,900 lbs.
Combat radius	220 miles	100 miles
Selection of target	Excellent	—
Dispersion of fire	Probable misses: 4/1,000	1/1,000 of distance
Continuity of action	intermittent	total
Vulnerability to jamming	nil	great
General characteristics:		
Combatants	35	—
First-line supporting personnel	250	150
Financial aspect	(estimated)	(estimated)
Capital investment	$20,000,000	$7,500,000
Annual maintenance cost (peacetime)	$4,000,000	$3,000,000
Ground organization	$4,000,000	$750,000

The uncertain and provisional character of this comparison is obvious. It is naturally very difficult to compile a comparative balance sheet of 2 weapon systems differing as much as these. The final figures resulting from the table vary widely as a function of the parameters employed, and it would be wise, at least to fix an order of magnitude, to assume other than optimum operating conditions. Thus, if it is conceded that the 25 aircraft which the fighter-bomber unit could throw into action simultaneously would be capable of launching more than 2 tons of explosive on to the same target, it is estimated, as a comparison, that only 6 of the 48 first-line missiles could be fired simultaneously on a single objective. It is clear that by increasing the number of launching ramps, but consequently also by increasing the bulk of the missile unit, a greater concentration could be obtained and a greater weight of explosive dropped on the same target at the same time.

Similarly, as regards the dispersion of fire, the comparison is not very valid. In the case of the fighter-bomber unit, the probable misses is the sum of the probable projectile misses, the misses provoked by the rocket launching device and by the aircraft itself, a rate which must still be multiplied by the human co-efficient represented by the pilot.

All this should be kept in mind when examining the above table.

From the financial point of view, emphasis is placed on both the capital investment and the current cost of keeping the two types of units in service. Naturally, the capital investment figures are limited to the first cost of all equipment and the cost of training the whole of each unit. Not considered, therefore, are capital investments of an industrial nature which in the final analysis permit the creation of fighter-bomber or guided missile units.

It will be noted that the major difference will lie in the cost of the armament in the period of actual combat. Needless to say, the rockets fired by the fighter-bombers do not compare, from the cost point of view, with guided missiles launched directly towards the target.

The crux of the problem is this: militarily speaking, there is little value in a comparison which consists, on the one hand, of the firing of about 500 rockets with a warhead of about 10 lbs. and, on the other hand, the launching of six guided missiles each with a warhead of about 1,600 lbs.

Finally, the comparison makes even less sense if the guided missiles are provided with atomic warheads.

4. The role played by the surface will grow in importance. As complete radar guidance and thorough surveillance of the air space will be necessary, more complex ground installations will be required. The ground organization will be modified to accommodate a vast electronic architecture, capable of dividing the atmosphere into compartments and permitting any sector to be controlled from a distance.

5. Reconnaissance, or rather familiarity with the enemy's sky and ground, assumes much greater importance. Some of the guided missiles themselves (television missiles) will help to secure this knowledge.

Industrially speaking, the era of the fantastic weapons will also have important consequences.

Convulsion or evolution of the aircraft industry?

What are the changes which the general introduction of guided missiles will provoke in the structure of the aircraft industry? Even now, with conventional flying equipment still in universal use, the growing production of electronics, as well as missile equipment and accessories of all types, will ensure a certain transition and soften the effects of the change-over. It is known that electronic equipment absorbs up to 40 percent of the cost of certain types of fighter even today, but it is obvious that all over the world the national aircraft industries have not yet adapted themselves even to the new technical and operational requirements of existing material. The reason is that aeronautical engineering has expanded into fields hitherto completely foreign to aircraft builders for the purpose of reaping some of the benefits of these auxiliary activities. Rather than effecting the very difficult conversion of parts of its own resources, the aircraft industry has resorted to the facilities of allied industries which, for example, had previously supplied its needs for electronic equipment. Instead of remoulding the existing engineering and production apparatus, a "shift" has been effected, whose amplitude will be greatly increased by the advent of the guided missile.

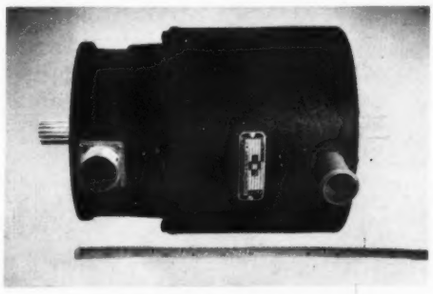
Do these changes represent a mere "shift," or do they amount to a convulsion? What will remain of the aircraft industry if the "pilots" seek refuge under slabs of concrete in order to watch the trajectories of their missiles on their radar screens? Not very much. Let us first examine the manufacture of airframes. With the exception of missiles of transoceanic range, the dimensions of the airframes will be totally different. Smaller covered surfaces will be required and, in general, much less space in the three dimensions. Yet, construction work will be anything but less intricate.—In view of the speeds to be attained, the machining quality must be as good as hitherto or better. Designers will have to find a compromise between their missile's finish and strength requirements and the savings which would result from cheap manufacturing methods adapted to their short life. For this purpose, new materials, such as plastics or ceramics, may partially replace the high-grade aluminium alloys and stainless steels. As regards the tooling equipment, it is unnecessary to point out that its characteristics will vary in accordance with the materials employed.

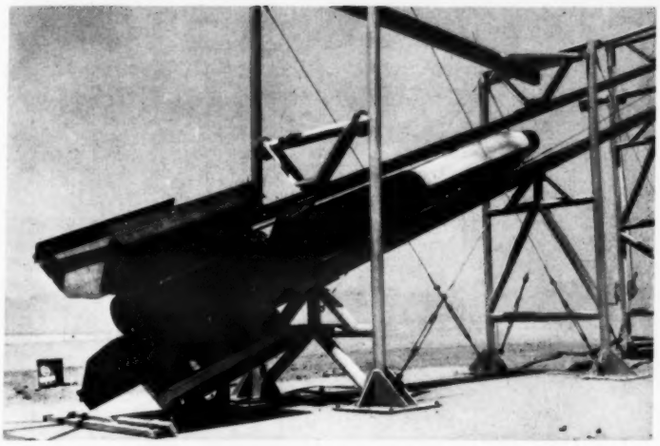
Power plant will be as important as the engines of conventional aircraft, both as regards actual weight and weight in relation to the gross weight. But in design and in machine shop work they will differ profoundly. While the airframe of the missile requires work of great precision, the life of the power plant is short enough to allow a relaxation of certain specifications.

Only the plants manufacturing equipment and accessories will continue to employ the same techniques and machine tools. The "cylinders" of a rocket motor have little in common with those of the piston engine. A ramjet hardly resembles a gas turbine engine, apart from the fact that it also has some form of burner and combustion chamber. But the very great consumption of the two types of power plant require high capacity pumps which must be produced in great quantity.

In the field of remote control—the reception and transmission of control impulses—the size of instruments must be greatly reduced. Furthermore, their resistance to high rates of acceleration and the sensitivity of their reactions must be improved, since the best missile will be the one with the greatest manoeuvring ability. Needless to say, one may be tempted to "oversimplify" the equipment of a guided missile, since the latter is expendable. However, in order to obtain perfection in final target approach guidance, ensured, for example, by those famous "electronic brains" reacting to heat, light or the mass of the target, the precision of a watch maker is required. In addition, new materials, with which the entire

Major problem to be solved by the guided missile engineers is the reduction in the size of the equipment and the latter's adaptation to working conditions at high altitude. Here is the electric compartment of a long-range guided missile: induction generator of AiResearch Manufacturing Co. for three-phase alternating current of 115/200 Volts; length, 9 inches; rotating speed, 8,080 r.p.m.





Fuel worries: Under the most favourable conditions a ramjet engine consumes 2.5 lbs. of fuel per pound of thrust per hour. Picture shows ramjet missile of Aerojet Engineering Corp.

Solid fuel rockets require up to 20 lbs. of fuel per pound of thrust per hour, rockets driven by hydrocarbon-nitric acid combinations need up to 16 lbs. Picture shows the Fairey delta-wing rocket exhibited at Farnborough in 1952.

aviation industry has never bothered so far, will have to be employed. Then there is the question of the fuels required for today's missiles, a problem which has not preoccupied the industry any more than the materials. Many of the new fuels, chiefly those of high efficiency, suitable density and acceptable storing and handling qualities, are not available in quantities sufficient for today's needs, and present supplies are wholly inadequate for the needs of an air force basing its strength on different categories of missiles. The laboratories must work on improving the efficiency of existent fuels and—this is equally important—an enormous industrial apparatus, possibly with some revolutionary new aspects, will have to be created. Whether nitric acid be required for one special type of missile, or hydrazine, nitromethane or even methyl alcohol for all of them, the quantities available at present are very low.

Does anyone remember that by the end of World War II in Europe, the Allied Forces were consuming gasoline at the rate of about 25 million gallons a day? In 1941, the National Advisory Committee for Aeronautics had estimated that the operation of a fleet of 50,000 aircraft would require about 7,500,000 gallons every 24 hours. This expert estimate was very far out as a result of the greater number of aircraft in operation and the greater specific consumption of their engines.

Furthermore, the United States alone produced 17,500,000,000 gallons of 100/130 octane gasoline (in other words, aircraft fuel) between Pearl Harbor and the capitulation of Japan. Today, we greatly exceed the specific consumptions prevailing at the time these estimates were made. The most efficient ramjet exceeds a consumption of 2.5 lbs. of fuel per pound of thrust per hour. The semi-expendable jet of a guided missile will exceed a consumption of 1.2 lbs. Rockets will need, at any altitude, about 20 lbs. of fuel per pound of thrust per hour, or nearly 25 times the consumption of the conventional engine (0.8 lbs. per pound of thrust).

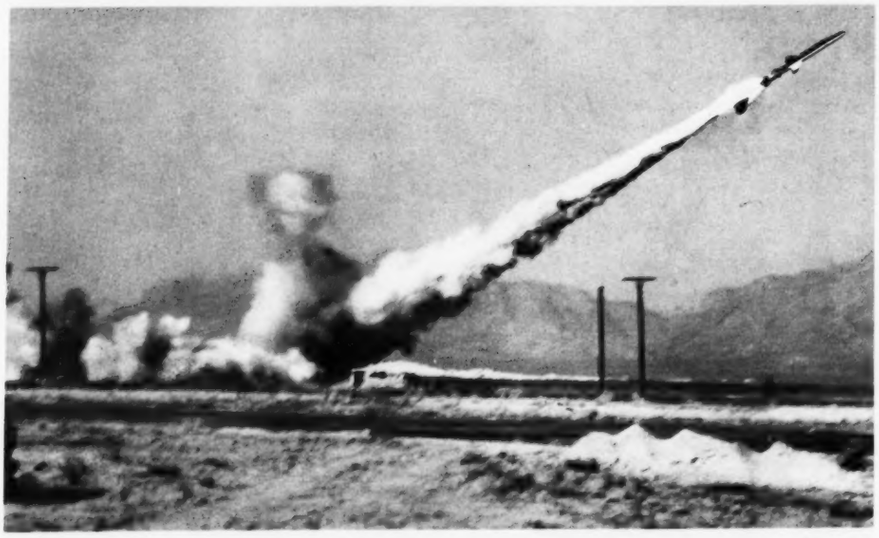
Certainly, in considering these rates of consumption, one should take into account the operational characteristics of the missiles which naturally differ greatly from those of piloted aircraft. For air defence purposes, as well as for the destruction of targets on the ground at short and medium ranges, flying times will be reduced in even greater proportion than the difference in consumption mentioned above. But the fact remains that the fuel problem is a very real one and that today it limits all legitimate ambitions.

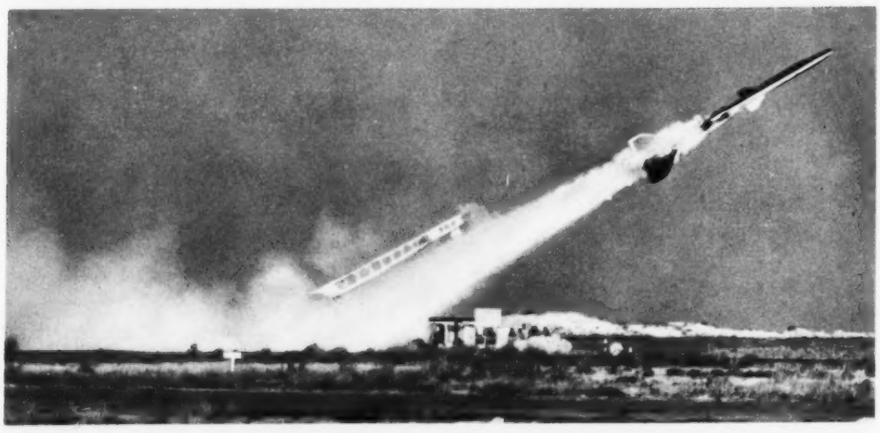
Let us now examine the manpower problem. The recruiting of manpower will not present any special problems in industrially highly developed nations. The only outstanding feature will be that the role played by scientists and control personnel will continue to gain in importance. It is also possible to foresee a greater dispersal of production units, since the quantity production of missiles lends itself to farming out to numerous sub-contractors. Without resorting to one-man workshops, it is certain that missile production, to a greater degree than aircraft manufacture, permits the decentralization of production and the enlistment of small factories. Scientific research and development are an entirely different matter, however. This field requires highly qualified scientific and engineering personnel, combined with an expensive concentration of research, computing and experimental facilities. Such a concentration of intellectual, technical and industrial wealth can be furnished only by the great population centres of our time.

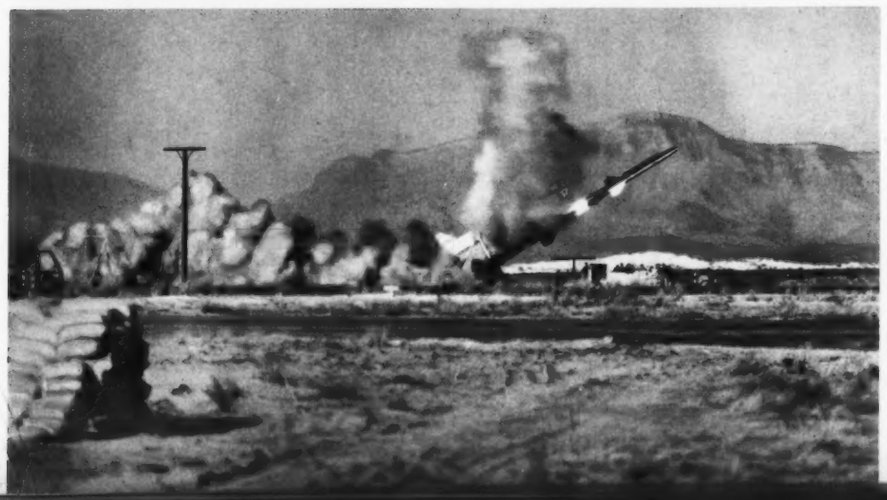
From this it will be seen that the advent of the guided missile may be the starting point of a revolution rather than an evolution. New raw materials, new fuels to be produced in quantity, a new structure of the production apparatus will result in profound changes of the industrial picture, both in the purely aeronautical field as well as in the allied industries. While the light-weight missile will make possible some kind of "back to the earth" trend by the wide use of the provincial or even rural workshops, this decentralization, or rather this vast dispersal of the manufacturing resources, would have immense advantages both regarding the invulnerability of the production apparatus and the industrialization of the countryside.

From the intellectual point of view, too, the conception and manufacture of purely expendable equipment, produced in vast quantities, necessitates an adjustment of ideas regardless of the size of the industry under consideration. Our conventional aircraft of today, with their multitude of control, guidance, navigation and firing equipment, are spearheading the transition by giving priority to electronics. The light semi-guided equipment of tomorrow —situated somewhere between the armed aircraft and the flying automatic weapon—might form another logical step... making an industrial revolution superfluous.

Thus, the revolution just predicted might not take place after all. Instead, a gradual evolution of the air arm and the industries serving it, may get under way. Nevertheless, the difference between old and new will be great. Compared with the aircraft of the "good old days," such as the *Spad, Morane, Hurricane, Sabre,* or even the B-17 or B-36, these latest developments raise the question of whether the era of "impersonal" weapons, the weapons "without a soul," is upon us. It is certain that the "first-line soldier" of tomorrow will be fighting in an entirely different way. In the green reflection of the oscillographs, wrinkled faces will light up with the appearance of the pip on their screens, and the computation of a scientifically sound interception will form the subject of conversations which in years gone by were animated by accounts of a nose-dive into the ground or a belly landing. But the manoeuvre in space, the mastery of prodigious forces or the precise control of infinitely small objects within the universe will fill human beings with the same pride as was formerly felt by the man who risked his own life for the benefit of his country... namely, the soldier.







Flying Robots

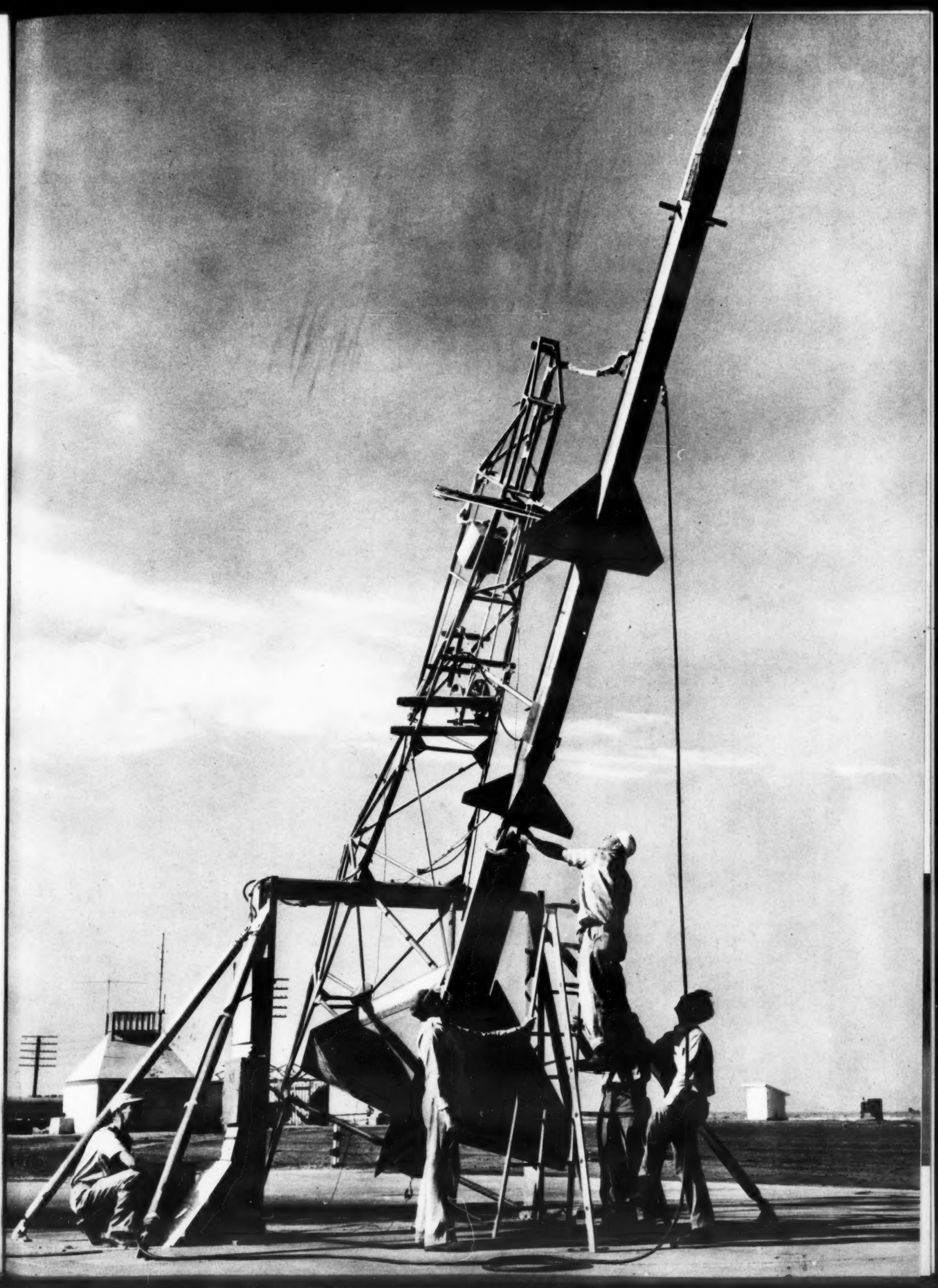
Boeing [illegible]ets over Alamogordo

The air over the dusty treeless wastes of New Mexico, between the Sacramento and San Andres mountains, has for years past been distinctly "metallic," for this is the site of two United States rocket-firing grounds, *White Sands Proving Ground,* belonging to the U.S. Army, and *Holloman Air Force Base, Alamogordo.* Both are quite close together and a bare 100 miles from the frontier town of El Paso.

Ever since the first V2s captured in Europe were tried out at White Sands the two bases have known constant activity. At White Sands the V2 was succeeded by the huge Convair 774 (Air Force) and Martin *Viking* (Navy) research rockets, and these were followed in turn by Army Ordnance designs. Alamogordo has been the scene of trials on smaller Air Force experimental rockets—in particular the North American NATIV (North American Test Instrument Vehicle) and the Aerojet-Douglas *Aerobee*—and a series of *anti-aircraft rockets built by Boeing Airplane Co.*

Shortly after the war Boeing started on a comprehensive development programme for remote-controlled anti-aircraft rockets, under the name of GAPA (Ground-to-Air Pilotless Aircraft). During this programme more than 100 experimental ascents were made. GAPA rockets reached cut-off speeds of around 1,500 m.p.h., or over twice the speed of sound.

The pencil-slim body of one of these rockets (right) measures roughly 27 ft., including its launching rocket. It has a delta tail unit (with tips of surfaces cut off obliquely) and cruciform delta-shaped control surfaces. The launching rocket is about 8 ft. long and has large cruciform delta guide surfaces. The rocket is launched under its own power, from a swivelling mounting, the two rocket motors in preliminary and main stage both starting up at once. Once it has burned out the launching rocket drops off. The pictures on the left shows some of the phases of the launching process. They were taken in 1949 but have been withheld until now for security reasons. Meanwhile the GAPA programme has been replaced by production orders for the Boeing F-99 *Bowmark* anti-aircraft guided rocket.



World Guided Missile Trends

BY MICHEL M. DECKER, HEAD OF THE GUIDED MISSILE SECTION, AIR MINISTRY, PARIS

Can a valid estimate of the current state of guided missile design and production in the various countries be attempted today, a mere ten years since the first serious efforts in this field ?

Admittedly, the very effective curtain of secrecy drawn over the development of all "new weapons" has made it very difficult to gather sufficient material for such an appreciation. The information available is not only scanty, but is for the most part concerned with marginal subjects, such as propulsion or aerodynamics, but not with the central problem, the missile as a whole and its control. In particular, while news of the existence and sometimes even fairly precise technical details of experimental missiles of various kinds are officially released, it is rarely possible to obtain reliable information on actual combat missiles.

Having made these reserves—and they apply especially to what it is permissible to reveal about French activity in this sphere—we shall nevertheless try to provide a general picture of the present situation from the military point of view. There will therefore be no discussion of experimental weapons, physical research rockets or target missiles.

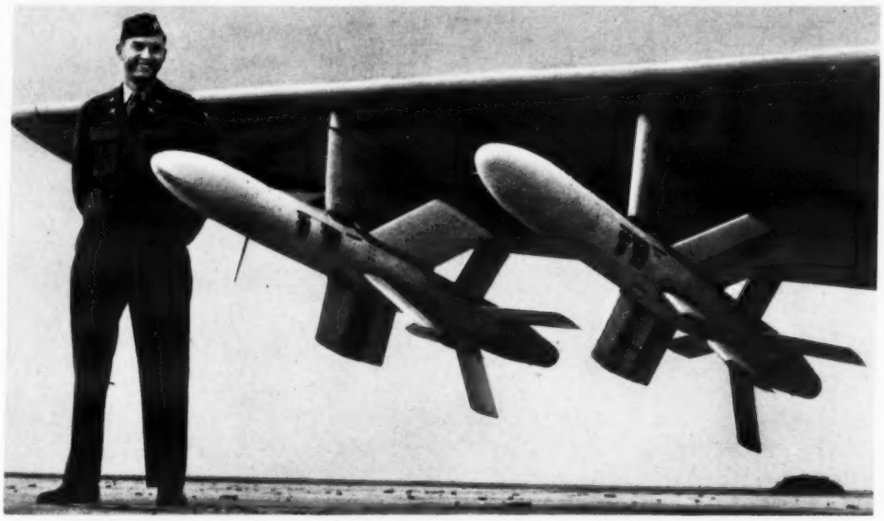
Four countries, the United States, Great Britain, France and Soviet Russia are responsible for the major part of world activity on guided missiles. Other countries, such as Canada, Australia, Italy, Sweden, are also experimenting on a smaller scale... and *Interavia* has published an interesting account of the work done on ground-air missiles by the Swiss firm of Oerlikon, Bührle Co., Zurich [1].

From the point of view of utilization, missiles are classified into four main groups : air-air, air-ground, ground-air and ground-ground. The first two are air-borne weapons and replace or extend the sphere of classical bombs and rockets, without, however, entailing any profound changes in the use of air power.

The two latter, on the other hand, are independent weapons which replace aircraft or shells for certain missions and extend their range from the military point of view. The ground-air missile, for example, has a field of utilization between the anti-aircraft shell and the interceptor fighter ; the medium-range ground-ground missile supplements heavy artillery, and the long-range ground-ground missile may in certain cases replace the strategic bomber.

The official statements made from time to time during budget discussions generally refer to the independent missiles. More specifically, when the Americans talk of the advent of "push-button" warfare, they are thinking simply of long-range ground-ground missiles.

Before embarking on the main part of our subject, the examination of the ground-air and ground-ground situation, we shall glance briefly at air-air and air-ground missiles.



Air-air : Fighter missiles of the Ryan *Firebird* type (experimental model with powder rocket and radio control) in the bomb racks of a North American F-82 *Twin Mustang*.

Air-ground : The American *Bat* radio-controlled glider bomb was used successfully in World War II.

[1] Cf. INTERAVIA, Review of World Aviation, No. 10/1951 : "*Slingshots or Precision Weapons.*"

Air-ground : American GB-4 glider bomb with television head and radio control ; warhead, 1,000 lbs.

In an article entitled "Aircraft Rockets," *Interavia* No. 10, 1951, gave a review of some of the weapons in these categories and their technical characteristics.

Air-air missiles

The necessity for air-air missiles in interception operations is now generally recognized. Because of the reduction in manoeuvrability of aircraft at today's high combat altitudes, traditional projectiles (shells and rockets) whose movement is purely axial in relation to the gunner are no longer sufficient, and it is necessary to compensate the aircraft's reduced manoeuvrability by a manoeuvrable projectile.

A number of aircraft in various countries are being fitted for such missiles. In some cases (e.g. Avro-Canada CF-100, North American F-86) provision is made for their use alongside other weapons, in others they are the only form of armament allowed for. This is particularly the case in the United States of the aircraft in the "1954 Interceptor" programme (Convair F-102) and certain French projects.

It is the work on air-air missiles that has produced the largest number of prototypes. Seven prototypes are reported in the United States, the best-known being the Hughes F-98 *Falcon ;* and this number probably does not include missiles which were built before the present programme and are more of an experimental than of a military nature. The Ryan *Firebird* is an example.

A number of missiles have also been designed and are flying in Great Britain, Canada and France.

On the whole it may be considered that the primary technical phase has been completed and that experiments in their tactical military utilization can now be made.

There is talk of production in quantity, but there has been no report so far of their having been used in combat, for example in Korea.

From the technical point of view, the air-air missile has the following general characteristics :

total weight about 220 lbs. (100 kg), including a warhead of 44 to 66 lbs. (20 to 30 kg),
length of 6 to 10 ft.,
powder rocket propulsion,
guidance by target-seeking device, e.g. radar, to take the missile direct to the aircraft to be intercepted,
speed of the order of M 2.

Air-ground missiles

The first guided missiles used were air-ground ones, and have from the beginning fallen into two distinct categories depending on their method of use : on the one hand glider weapons, propelled or otherwise, such as the American BAT or GB4, or the German HS 293 ; on the other hand bombs with trajectory correction and rapid vertical movement, such as the American Azov and the German FX.

Work on this category of missile forms only a small part of total activity. The technical problems here are, moreover, relatively the least difficult.

Ground-air missiles

If the two categories of guided missile discussed briefly above raise no problems of doctrine, the same cannot be said of those we are to examine below.

The use of classical means of interception encounters serious technical limitations, for example the ceiling of anti-aircraft artillery and the time of climb of an aircraft to a given altitude. The ground-air missile provides a means of overcoming these limitations, but technical considerations must then be accompanied by a study of the economic factors involved. One thing seems certain : the cost of interception by ground-air missiles would be very high.

The press recently published an estimate that the defence of a city the size of Washington by means of Boeing GAPA missiles against one raid by 250 bombers would cost approximately $40,000,000 ; such a figure would obviously make the military hesitate to engage on so costly a course.

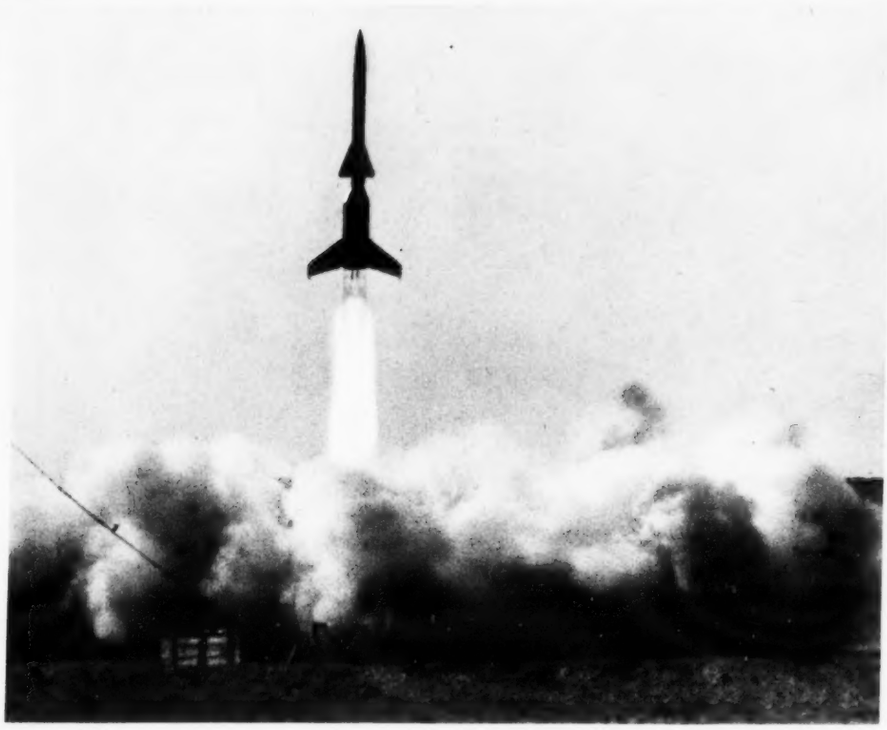
However, reliable estimates of this kind are very difficult to make : too many factors are still unknown, and the approximations it is thus necessary to use introduce a considerable element of the arbitrary. What is even more disturbing is the fact that a calculation of this kind may be influenced unconsciously but to a noticeable extent by the result it is desired to obtain. We shall therefore not give any calculations of our own.

Air-ground : The ROC controlled precision bomb was designed for high-angle release. Radio impulses to servo motors adjusted the steering ring. A "television eye" was also fitted in the bomb tip.

Ground-air : A U.S. Army Ordnance two-stage anti-aircraft rocket (Douglas *Nike*) taking off from the White Sands proving grounds, near Las Cruces, New Mexico.

Nevertheless, it seems likely that the ground-air missile will eventually make a place for itself between artillery and aircraft, for both technical and economic reasons. This place will probably be a smaller one than that forecast by those who prophesy the disappearance of the fighter.

Mr. Duncan Sandys, Britain's Minister of Supply, and his experts recently expressed the opinion that a single type of rocket missile flying at Mach 3, controlled at first by radar from the ground, then guided to its target by target-seeking radar, would supply the answer to all air attack problems. This is probably going too far, though on the other hand the ground-air missile should not be regarded merely as the extension of classical anti-aircraft artillery.



Ground-air : In France Société MATRA has also developed an anti-aircraft rocket.

In any case, technical developments are not yet so advanced that tactical experiments can be carried out on a sufficient scale to make possible a theory of employment founded on practical experience. Although there is talk of quantity orders, several years of operating tests will be needed to reach this point. Work is going on feverishly in the United States, Britain and France on programmes which seem to be fairly varied from the point of view of the guiding systems used and the performance, particularly the range, aimed at.

For the first part of the trajectory, at any rate, indirect automatic guidance on an electrical axis aimed from the ground, the beam rider system, enjoys universal favour.

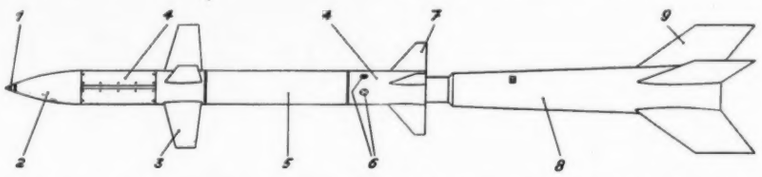
Study of guided missiles in general is extensive, particularly because of the fact that all three services consider themselves directly concerned in the future exploitation of this type of equipment.

In the United States the best-known missiles are the Air Force's Boeing F-99 *Bowmark,* the Navy's Convair *Terrier* and Army Ordnance's Douglas *Nike.* They have been prepared for some years past by the launching of experimental missiles such as the GAPA and the *Lark.*

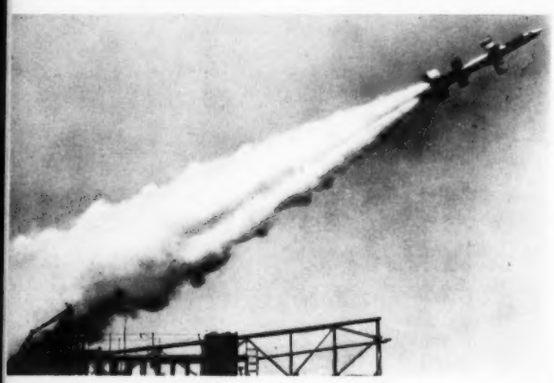
In Great Britain Mr. Sandys revealed last summer the existence of a guided missile in a very advanced stage of development, and in France it has already been possible to publish certain details of the results obtained by SNCASE and Société MATRA in experiments preceding the building of practical missiles.

The designs adopted for ground-air missiles are very varied, not only from the technical point of view (nature of propulsion and method of launching for example) but also in basic principles. It can almost be said that there is a continuous series of intermediate designs between the aircraft and the pure projectile, apart from the fact that the fitting of a projectile with a minimum of aerodynamic organs to make of it a guided missile ranges it alongside the aircraft.

This continuous development is marked at intervals by unmanned aircraft of the "Interceptor 1954" class, by long-range missiles (60 to 120 miles) and by medium-range missiles (30 miles). The Russian CZ 2 B missile with vertical launching is a good example of the general continuity in development.



Ground-air : Diagram of the Convair *Terrier* anti-aircraft rocket for the U.S. Navy : 1. fuse ; 2. warhead ; 3. cruciform wings ; 4. controls ; 5. propellant tanks ; 6. electrical connections ; 7. cruciform control surfaces ; 8. launching rocket ; 9. cruciform control surfaces of launching rocket.

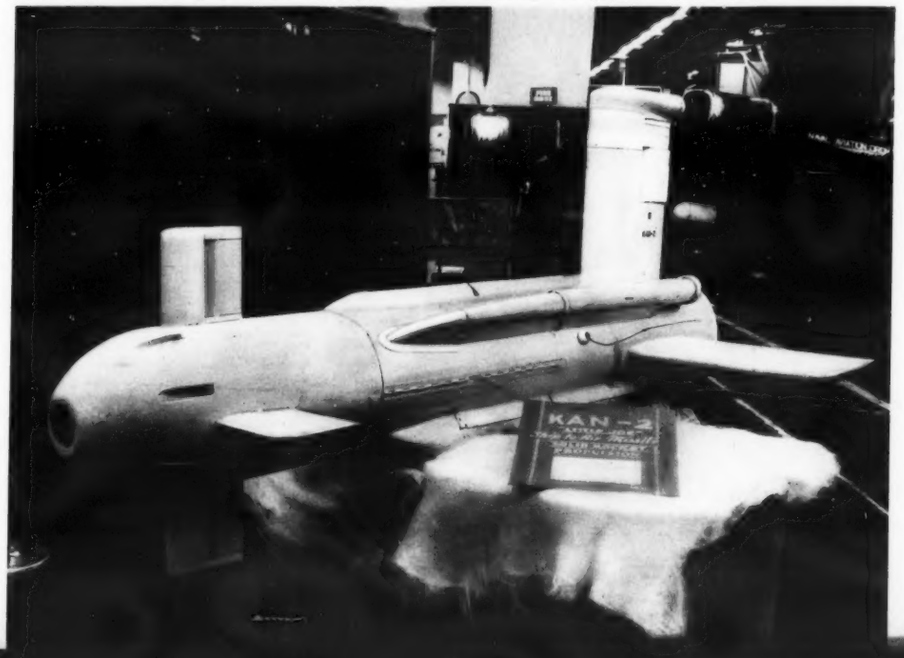


Ship-air : Launching the U.S. Navy's Fairchild *Lark* experimental rocket (liquid-fuel rocket plus powder launching rocket).

Ground-ground missiles

The intercontinental missile occupies a great deal of attention today. Thomas K. Finletter, Air Force Secretary in President Truman's Administration, stated a short time ago that his country would soon possess a guided missile

Ship-air : The U.S. Navy's KAN-2 *Little Joe* powder rocket was designed to protect naval units from air attack.



Ground-ground : The U.S. Army Ordnance's *Hermes* family (here the Hermes A-1) during its ballistic firing process.

capable of accurately hitting a target on the other side of the ocean.

This type of mission has been envisaged for nearly ten years . . . except for the direction in which it would operate. We all remember the German's A9-A10 project and its 3,000-mile range.

The guiding system in such a programme is obviously of major importance, at any rate to an extent related to the efficiency of the warhead carried. It is certain that the practical possibility of making atomic warheads reduces the demand for precision so that missiles can be designed and perfected more rapidly. On the other hand the dropping of an H-bomb by a manned aircraft also presents a difficult problem, because of the bomb's devastating effect. Some experts consider that this method of launching is out of the question, except of course for suicide aircraft, which however are not seriously considered by the majority of users. It would thus be essential to use a guided missile for the hydrogen bomb.

The problem of guiding over distances of several thousand miles has long since been tackled in the United States from several directions, all based on normal methods of navigation, particularly celestial and radio navigation, rendered automatic. It will be remembered that as long ago as 1947 a Skymaster made the first flight across the Atlantic without intervention from the crew, covering 2,600 miles from airport to airport.

For intercontinental flight the ballistic technique of the A9-A10 or of Dr. Sänger's project appears today to have given way to that of classical flight. The missiles of the 5,000-mile class under development in the United States, in particular by Northrop—and perhaps the *Snark*—apparently have the general configuration of jet-powered aircraft.

On the whole, then, it would seem that the advent of such missiles is not so far distant. The first will probably be converted aircraft. To claim at this point that they will completely replace strategic bombers would be going too far. The line, of which some maintained in 1950 that the B-36 would be the last, is probably still far from extinction.

Not all strategic operations by guided missiles will require such long ranges. Another class of missile with a range of 500 miles has been developed in the United States. In these, ballistic and flying forms are found side by side. The former is represented by Army Ordnance's *Hermes* family, preceded by well-known experimental missiles like the WAC Corporal and the spectacular composite Bumper. The second is used by the Air Force and the Navy in the Martin B-61 *Matador* and the Chance-Vought *Regulus*, both of them jet-powered aircraft.

Here too, the first models will probably be converted aircraft, such as the guided *Hellcats* which the United States Navy has used in Korea.

For tactical operations a number of projects with still shorter range are being examined, in particular in France, and are giving rise to designs which could be put into practical use shortly.

*

To sum up, it has become possible this last year or two to see more clearly what place will be occupied in the coming years by the various classes of guided missile.

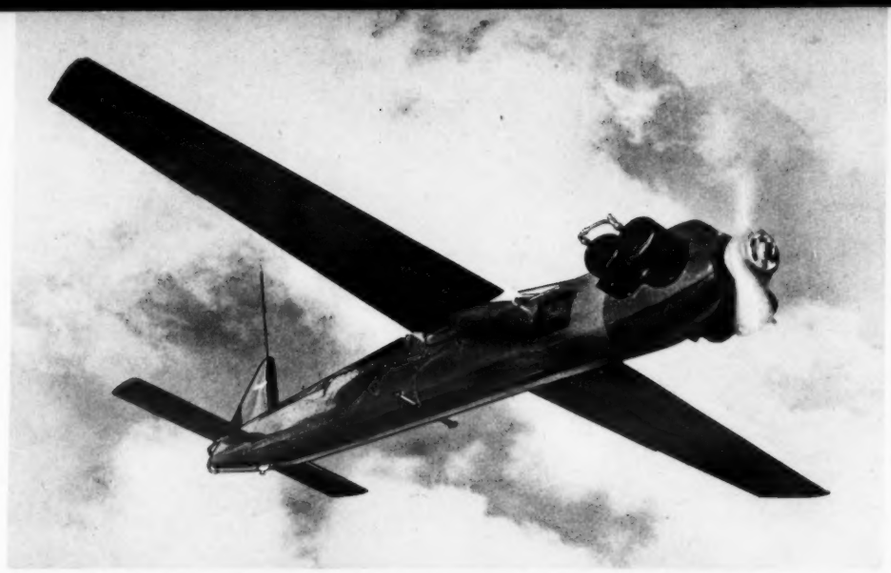
The year 1952 will have been particularly noteworthy in this respect in some countries.

To appreciate what can be expected of guided missiles in use, the whole set of circumstances at any given period must be examined.

Two essential parameters govern these possibilities on first examination : on the one hand, the technical results which can be used as a basis ; on the other, the resources of manpower, finance, etc., which it is decided to devote to the exploitation of these results. But the two parameters are not entirely independent, since the technical results available at any given time themselves depend on the resources that have been put into their earlier stages. To be exact, the position at a given moment depends to a large extent on a degree of confidence at the outset and in succeeding stages. It is certain, for example, that the confidence which Mr. Churchill has recently expressed in new weapons, particularly guided missiles, will have a marked influence on the future development of British missiles.

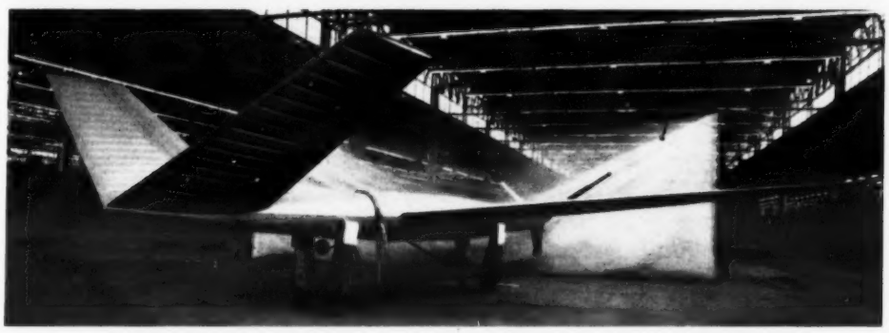
Ground-ground : The U.S. Air Force prefers a pure flying procedure : the Martin B-61 "Matador" robot bomber. (Launching rocket falling off.)

Target Aircraft



The U.S. Air Force's Radioplane OQ-19D radio-controlled target aircraft, with 72 h.p. engine and fixed pitch wooden propeller.

Like the sportsman and his game, the wild animal and its prey, guided missiles and target aircraft are at opposite poles. In view of their diametrically opposed uses, it may at first glance seem rather surprising that target aircraft should be given a place in the present issue. Yet they have certain technical features in common with guided missiles, so that it is possible to draw conclusions about the latter from the target aircraft. As the makers of "harmless" target aircraft are much less secretive about their products than the producers of guided missiles, the following review may help to round off the picture of guided missile development up to the present day.



The Chance Vought X27A is designed for towing speeds of up to 450 m.p.h. and high altitudes.

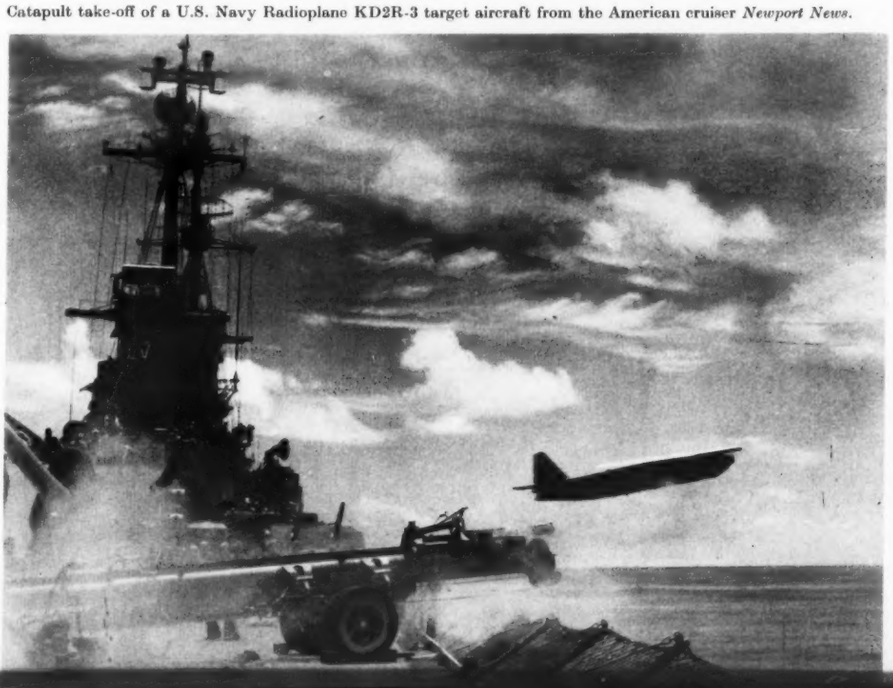
A bare fifteen years ago target banners and sleeves towed in leisurely manner through the air by slow military transports were still the most important practice targets for anti-aircraft artillery and fighters. The "flying carpets" of pre-war days had a speed of about 200 m.p.h. . . . at altitudes of 13,000 ft. to 20,000 ft. Neither course, height nor speed could be changed during firing.

Since speed and operating altitude of combat aircraft have been roughly trebled by jet propulsion, more realistic practice targets are required. The "game-birds" for today's gunners and pilots—not to mention rocket gunners—must resemble the supposed enemy as closely as possible, in speed and manoeuvrability as well as in shape and size. They must also be of metal construction, so that the air raid warning service's radar instruments and the radar sights of the ground and aircraft guns can pick them up. Finally, it is considered particularly important that they be self-propelled, so as not to endanger the towing aircraft otherwise required. Other requirements : cheapness ; robust structure ; ease of repair ; medium size (compromise between realistic presentation and economy).

Target aircraft fall into five categories, depending on their type of propulsion :

The U.S. Navy's Globe KD6G-1 radio-controlled target aircraft is also fitted with a 72 h.p. engine and fixed pitch propeller. Level speed 230 m.p.h.; endurance 1½ hours.

Catapult take-off of a U.S. Navy Radioplane KD2R-3 target aircraft from the American cruiser *Newport News*.



— unpowered towed kites ;
— propeller-driven, unmanned aircraft ;
— target aircraft with pulse-jets ;
— target aircraft with gas-turbine jets ;
— target aircraft with ramjets.

Take-off methods include cable towing (for target kites), pick-a-back carriage on the fuselage or wings of a "mother aircraft" (for ramjet aircraft) and, above all, catapult take-off and take-off under own power with auxiliary undercarriage. Landing is made as a rule by means of parachutes or, more rarely, on skids.

Free flying targets naturally need good automatic stabilization (gyroscopes) and at least pre-set controls or, better still, a radio control installation. The latter is usually in the form of tone-modulated impulse control, combined with a radar apparatus, or, in some cases, an optical sight. In the target a pulse receiver and a pulse repeater (identification friend-foe) are required ; the rest of the equipment is housed on the ground or on board ship.

Unpowered towed kites

RFD Target Ltd., in Great Britain, and *A.B. Flygmal,* in Sweden, build medium-range wooden target drones, for towing speeds of up to 280 m.p.h. (behind a Fairey *Firefly*). They have a wing of symmetrical profile, with a span of 30 ft., and two tail booms with landing skids. Weight 242 lbs., drag (for a towing speed of 250 m.p.h.) 190 to 355 lbs. depending on length of cable. The kites are cheap to build and simple to repair. They land on their skids.

In the United States *Chance Vought,* a division of United Aircraft Corporation, are the first to have produced a target drone of all-metal construction, designated the *X 27 A.* It has a very thick wing spanning 24 ft., a spindle-shaped body and a butterfly tail unit. It is towed by jet aircraft on a steel cable 1,000 to 12,000 ft. long to altitudes of up to 32,000 ft. Speeds of up to 450 m.p.h. can be reached. After release the drone lands on skids and is braked by a landing parachute which opens automatically.

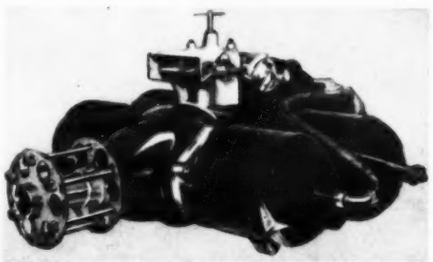
Propeller-driven target aircraft

Radioplane Company, Van Nuys, California (taken over in the summer of 1952 by Northrop), has been working exclusively on radio-controlled powered aircraft for target simulation since 1940. In twelve years it has turned out no fewer than 30,000 of these costly toys for the U.S. Army, Navy, Air Force and National Guard. The Army, for example, used Radioplane target aircraft for simulated Kamikaze attacks, to train its anti-aircraft gunners to counter Japanese suicide aircraft.

The latest link in the chain of development is a 72 h.p. all-metal model designated *OQ-19D* by the U.S. Air Force and *KD2R-3* by the Navy. The aircraft is in quantity production (Radioplane Co.'s present backlog of orders is $18,800,000). With a span of approximately 11 ft. 5 3/4 in. this shoulder-wing monoplane reaches speeds of 230 m.p.h. Power plant is the reliable McCulloch 4318A four-cylinder two-stroke horizontally opposed engine, which develops 72 h.p. at 4,100 r.p.m. It drives a fixed pitch wooden propeller. The engine is 27 inches wide and weighs only 77 lbs., without the propeller hub. A two-position solenoid actuates the carburettor throttle valve.

The drone is usually launched by catapult, though it may on occasion be carried aloft by a mother aircraft. As soon as the target is in the air it makes all subsequent manoeuvres with the ease of a fighter bomber, including dives and narrow turns. Two control surfaces only are needed, elevators and ailerons, both of which are operated by electrical servos by means of radioelectric and gyroscope impulses. The receiving aerial for radio impulses is at the tip of the fin. The OQ-19 lands by parachute (also if hit) and can therefore be used repeatedly.

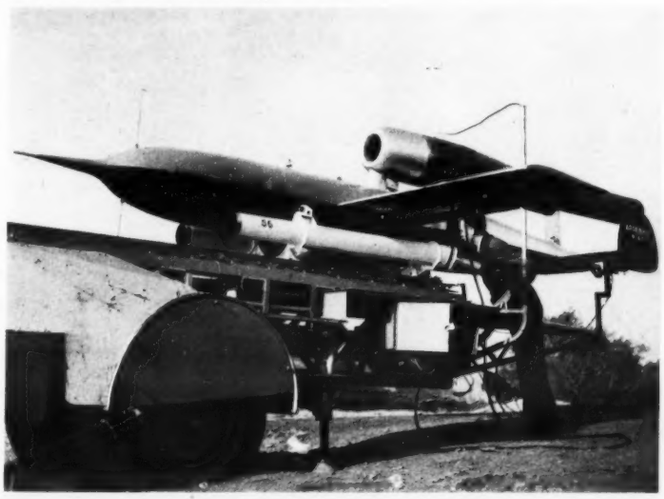
Another important American firm, the aircraft division of the *Globe Corporation* (formerly Frankfort Sailplane Co.) of Joliet, Illinois, and Williams Bay, Wisconsin, has also been producing radio-controlled target aircraft since 1942. Its best-known post-war models are the KDG-2 (35 h.p.), KD6G-2 (72 h.p.) and KD6G (100 h.p). The last-mentioned, with a *Kiekhaefer* air-cooled in-line engine (85/100 h.p), has a speed of about 265 m.p.h. and an endurance of about one hour : catapult take-off, radio control, parachute landing, span 11 ft. 5 3/4 ins., length 10 ft. 6 ins., height 1 ft. 7 3/4 ins., tail span 3 ft. 7 1/4 ins.



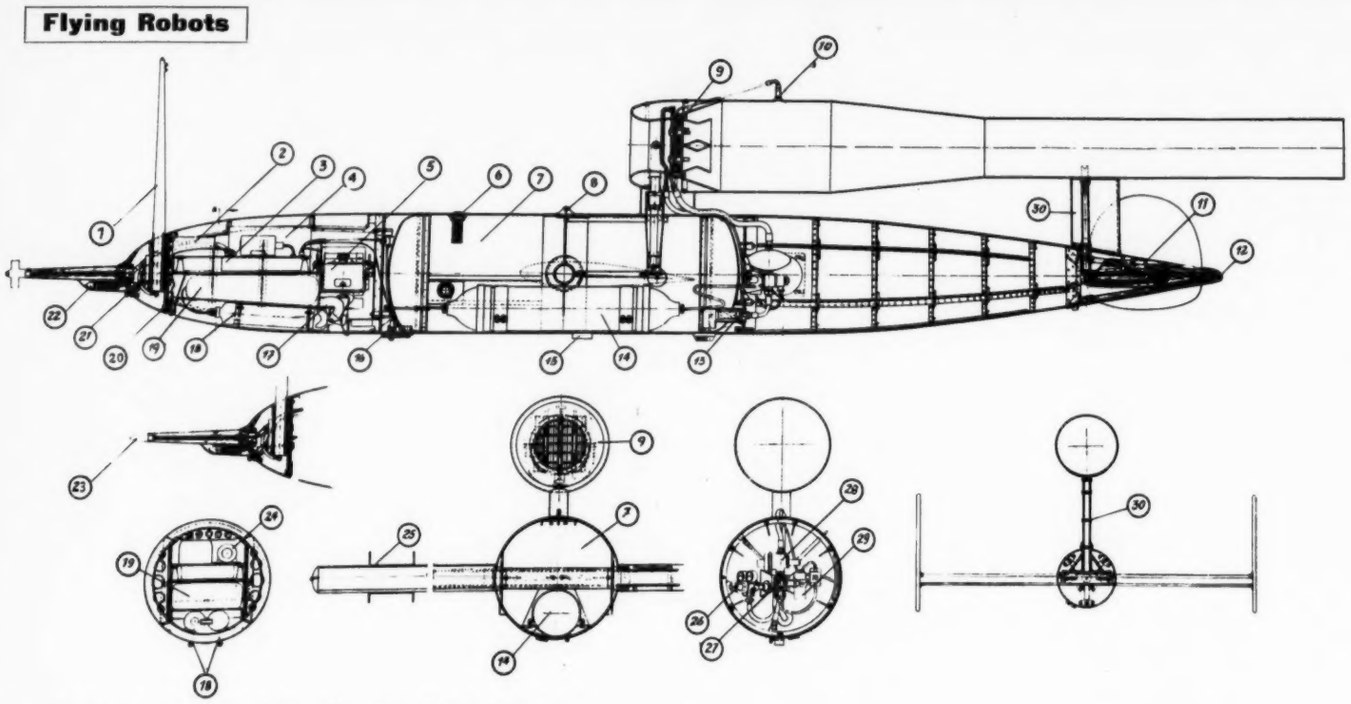
Power plant of the Radioplane OQ-19D and KD6G-1 target aircraft is the McCulloch 4318 A two-stroke horizontally opposed engine, which delivers 72 h.p. at 4,100 r.p.m.

ARS.5501 taking off. The two rockets on the take-off trolley and the pulse-jet in the aircraft are running at full power. A little later the trolley drops off.

The Arsenal ARS.5501 radio-controlled pulse-jet target aircraft (France) with rocket take-off trolley on a mobile ramp.

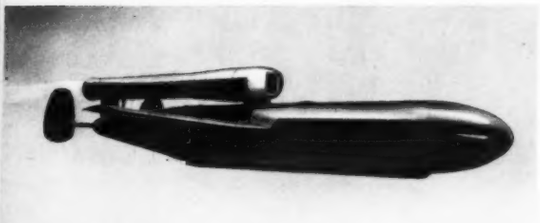


An ARS.5501 being fished up for further use after coming down in the water.



Sectional drawing of one of the earlier versions of the French target aircraft.

1. Aerial
2. Impulse receiver
3. Measuring transmitter
4. Automatic pilot
5. Accumulator
6. Filling point
7. Fuel tank
8. Hoisting lug
9. Louver
10. Starter Plug
11. Servo motor
12. Parachute lug
13. Fuel filter
14. Compressed air bottle
15. Outboard electric connection
16. Explosive bolt (for emergency emptying)
17. Straps (parachute)
18. Landing rocket
19. Parachute
20. Explosive bolt (for parachute)
21. Explosive bolt (for sonde)
22. Sonde (for parachute)
23. Pitot tube (for automatic pilot)
24. Transformer
25. Wing flap
26. Pressure reducer
27. Fuel cock
28. Fuel regulator
29. Starter igniter
30. Power plant console



The Globe XKD5G-1 (USA) target aircraft with a Marquardt P5-46 MA-2 pulse-jet engine of 175 lbs. static thrust.

In Great Britain the firm of *M. L. Aviation* has made a name for itself as makers of remote-controlled targets with 65 h.p. motor cycle engines and wooden propellers. One of them was shown at Farnborough in 1952.

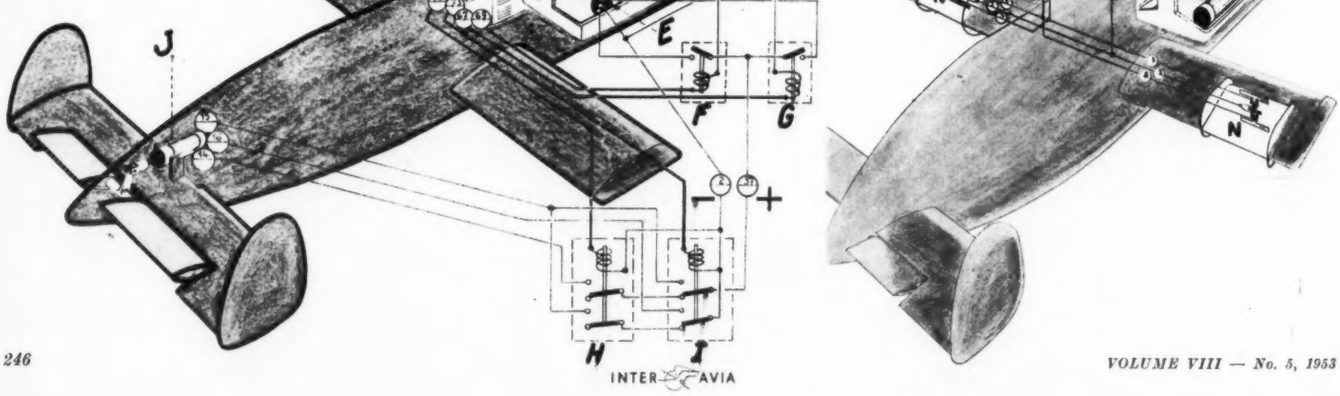
Target aircraft with pulse-jets

The best-known winged robot with jet propulsion is probably the French *Arsenal 5501* all-metal mid-wing monoplane developed by Arsenal de l'Aéronautique (now taken over by SNCA du Nord and renamed SFECMAS), and exhibited at the 1951 Paris Air Show. From a distance it looks like a dwarf descendant of the German V1 and, like the latter, is fitted with a *pulse-jet* on top of the fuselage. Unlike the V1 (which flew straight ahead on a predetermined course) direction is controlled and the aircraft stabilized about its longitudinal axis by means of electromagnetically operated wing flaps, *not* by rudder deflections.

The Arsenal 5501 spans 14 ft. 3 ins. and is 19 ft. 8 ins. long. With a wing area of 40.4 sq.ft.

Diagram of guiding installation in the aircraft *(left)* of the Arsenal 5501 pulse-jet target drone.

A. Radio receiver
B. Gyrometer
C. Gyroscope
D. Contacts for parachute release
E. Electro motor for turns
F. Relay for right turns
G. Relay for left turns
H. Relay for descent
I. Relay for climb
J. Electro motor for elevator
K. Relay for rolling
L. Gyrometer
M. Gyroscope
N. Electro magnet for wing flaps



Ryan Q-2 *Firebee* radio-controlled target aircraft with Fairchild J-44 turbojet and swept wings : the *Firebee* being prepared for take-off on an auxiliary take-off gear (left), carried up to operating altitude by a mother aircraft (centre) and leaving its mother aircraft, a Douglas B-26 *Invader* (right).

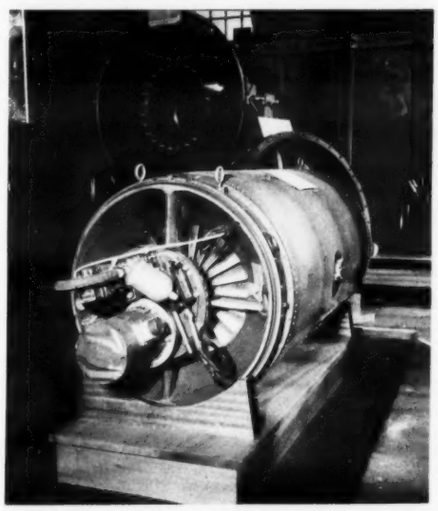
(single-spar rectangular wing), it has a gross weight, without take-off trolley, of 1,479 lbs., made up of airframe 590 lbs., power plant 179 lbs., equipment and parachute 218 lbs., fuel 481 lbs., compressed air 11 lbs. The power plant is a pulse-jet of the firm's own design—intermittent combustion with a pulse frequency of 45 c/s—which runs on normal commercial petrol and delivers a static thrust of 330 lbs. at sea level. Flying thrust *decreases* with increasing speed.

The robot is launched with engine running from a 40-ft. steel tube ramp, which can be either fixed on the ground or mounted on a mobile trailer. Launching angle as a rule is 5 degrees. Two solid propellant rockets of 13,230 lbs./sec. momentum, placed symmetrically on the launching trolley, increase take-off thrust. They continue to burn after leaving the ramp, then descend by parachute, together with the trolley. The weight of the launching trolley is 557 lbs., including 141 lbs. for the rocket propellant.

For remote control during flight there are five "commands" which can be given from the ground station, following the indications of an optical sight. They are higher, lower, left, right and land—and are superimposed on the same VHF carrier frequency (109.08 mc/s) with the aid of varying tone modulations (300, 650, 1,400, 3,000, 6,400 c/s). The "landing command" is also given by an automatic device in the target in the event of breakdown.

The relays for climb and descent are connected direct with the electric servo motors for the elevator. In normal "cruising flight," however, the elevator is blocked, and the single-axis automatic pilot acting on the wing flaps stabilizes the aircraft about its longitudinal axis. To initiate a turn it is sufficient to move the frame of the reference gyro to the right or left using a small relay-operated electro-motor.

The "landing" command sets off a whole series of operations : reception of all radio signals is blocked ; petrol cock closed ; tank emptied by compressed air ; parachute box opened by explosive bolt.



Fairchild J-44 short-life engine of 950 lbs. static thrust : length 72 ins., diameter 22 ins., weight 325 lbs.

A pilot parachute then pulls the main parachute out of its container and the aircraft floats, nose down, to the ground. Its point then bores into the ground, if the latter is soft enough. On hard ground, or in windy weather, it may fall over, but even then damage is generally slight. If it comes down on the water it floats, being empty, and can be picked up by salvage boats.

Performance of Arsenal 5501 : level speed at low altitude 260 m.p.h.; at 13,120 ft. 285 m.p.h.; climb to 13,120 ft. in ten minutes ; endurance 30 to 45 minutes ; service ceiling 16,400 + ft.; range of radio control 31 miles.

In the United States *Globe Corporation* produces pulse-jet target aircraft of a similar kind, also of all-metal construction. They have been designated the *Globe KD2G-2 and KD5G-1*. The latter has a *Marquardt PJ-46. MA-2* pulse-jet, with a diameter of 10.6 ins. and a sea-level static thrust of 175 lbs., span 11 ft. $^3/_4$ ins. The two American robots are said to have speeds of 230 m.p.h. and 340 m.p.h. respectively. Their endurance is 35 to 75 minutes.

The *Jindivik* target aircraft built by the Government Aircraft Factory, Melbourne, Australia, is fitted with a British Armstrong-Siddeley *Viper* short-life engine of 1,500 lbs. static thrust and takes off under its own power. The take-off trolley has automatic brakes.

Flying Robots

A mother aircraft carries the Martin KDM-1 *Plover* target aircraft to operating height. The latter has a Marquardt RJ-30-MA-6 ramjet and ultra-thin swept wings, and lands by parachute.

The Martin KDM-1 *Plover* in quantity production.

Jet-powered target aircraft

As is now generally known, turbojet engines are not exactly cheap. If they are to be used for such short-lived apparatus as target aircraft, everything possible must be done to reduce production costs. The line of development here leads inevitably to the "short-life engine" designed to run only a small number of hours. Three engines of this kind are available, the Fairchild J-44 (USA ; 950 lbs. static thrust), the Armstrong-Siddeley *Viper* (Great Britain ; 1,500 lbs. thrust) and the Turboméca *Marboré II* (France ; 840 lbs. thrust) and its American licence version, the Continental J-69.

The American *Ryan Q-2 Firebee* target drone, made by Ryan Aeronautical Co., San Diego, California, the first to have swept wing and tail, is fitted with one of these short-life engines, the Fairchild J-44, which gives it a *speed of over 600 m.p.h.* The *Firebee* is generally carried up to operating height by a "mother aircraft," started up by the latter, released and then guided from a ground station. When its fuel load has been consumed, the drone reduces speed and lands by means of a large parachute. The latter also comes into operation when the drone is hit or has an engine failure, or radio communications are cut. The ground station can of course cause the drone to land at any desired moment. As the aircraft touches the ground the parachute is automatically released.

The *Firebee* has a span of 12 ft. and a length of 18 ft. Gross weight is approx. 1,800 lbs. First glide tests were made in March 1951, and tests with engine running began in the summer of the same year at Holloman, New Mexico. Today the *Firebee* is in quantity production.

Similar developments have been going on in the Antipodes, where the *Government Aircraft Factories,* of Melbourne, Australia, have produced the *Jindivik* unmanned all-metal target aircraft, based on British Ministry of Supply specification E7/48. Its engine is an Armstrong-Siddeley *Viper* of 1,500 lbs. thrust, weighing 365 lbs. The *Jindivik* has a rectangular wing with thickness-chord ratio of 10% and a span of 19 ft., low wing loading and low aspect ratio (4.75). It takes off under its own power on an auxiliary take-off gear which is automatically braked as the aircraft takes off (or, more exactly, when take-off speed is reached), and remains behind on the ground. The aircraft lands on a retractable sprung skid. The *Jindivik* is controlled from the ground by radio during flight. Several target aircraft of this type have been under test at the Australian rocket research centre at Woomera for the past year.

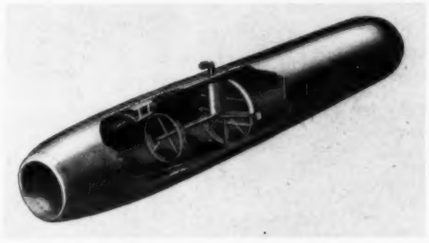
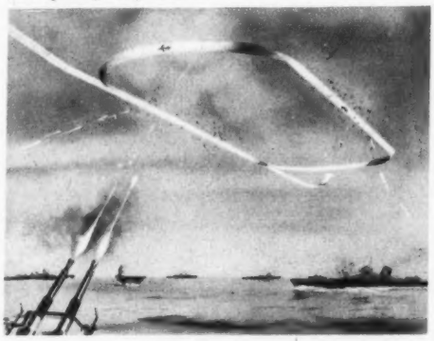


Diagram of a Marquardt subsonic ramjet.

Ramjet-powered target aircraft

Unmanned aircraft with ramjet engines are the smallest robots used for target purposes. The latest of them, the *Martin KDM-1 Plover* built by The Glenn L. Martin Co., Baltimore, Maryland, spans only 10 ft. for example (length 22 ft. 4 ins.). Its predecessor, the KUM-1 *Gordon IV,* made by the same firm,[1] had almost the same dimensions.

Target practice for the anti-aircraft guns of a carrier task group on Martin KDM-1 *Plover* radio-controlled target aircraft. In the background one of these targets is just completing its robot flight, going into a steep drive and opening its parachute.



The *Plover* is an all-metal high-wing monoplane with sharply swept thin wing and tail surfaces. The Marquardt RJ-30 subsonic ramjet, 7 ft. long and $1^3/_4$ ft. thick, is suspended beneath the long thin fuselage. It has a weight of 125 lbs., and its makers claim for it "more than 1,400 lbs. thrust," doubtless at maximum speed and with rich mixture. (At half the maximum speed only about 20% of full thrust can be expected ; a ramjet has *no static thrust.*) Radio control equipment and automatic pilot instruments for stabilization are carried in the nose, and the parachute in the tail.

The *Plover's* performance is veiled in the deepest secrecy. It may be assumed that it reaches very high subsonic speeds (600 to 700 m.p.h.) but cannot cross the sound barrier, as a different shaped ramjet pipe (supersonic diffusor) would be needed for this.

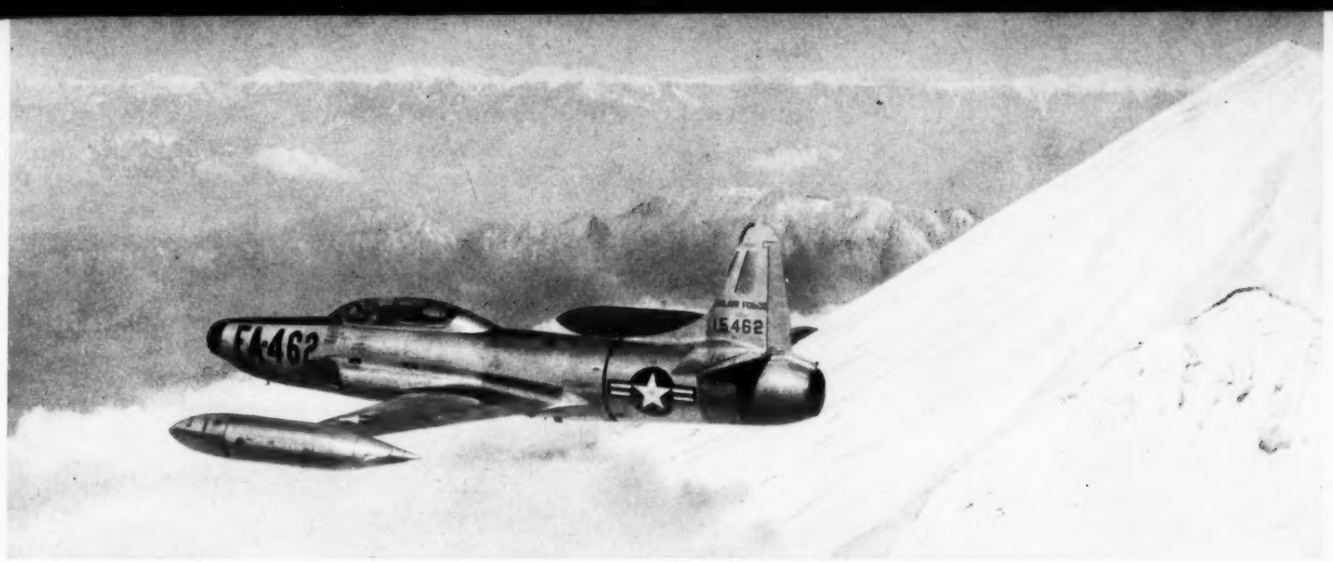
Finally it should be mentioned that the French *Arsenal de l'Aéronautique* (now SFECMAS) has been working on pilotless aircraft with pure ramjet engines for some time. Result : a ramjet pipe 2 ft. in diameter which delivers a thrust of 1,000 lbs. near the ground (at 620 m.p.h.) and of 220 lbs. at 40,000 ft. (at 560 m.p.h.).[2] Engineer René Leduc is also working in the same field with his *pilotless Leduc 010* and *Leduc 021* experimental aircraft.

*

From remote-controlled target aircraft to remote-controlled winged shells is only a step. Progress made on target aircraft automatically benefits guided missiles. The only other type of power plant that can be used for the latter is the *rocket engine,* which is obviously not an economical proposition for a target aircraft.

[1] Cf. INTERAVIA No. 2/1949, pp. 84-86.

[2] Cf. Technique et science aéronautiques, No. 3/1952, p. 150.

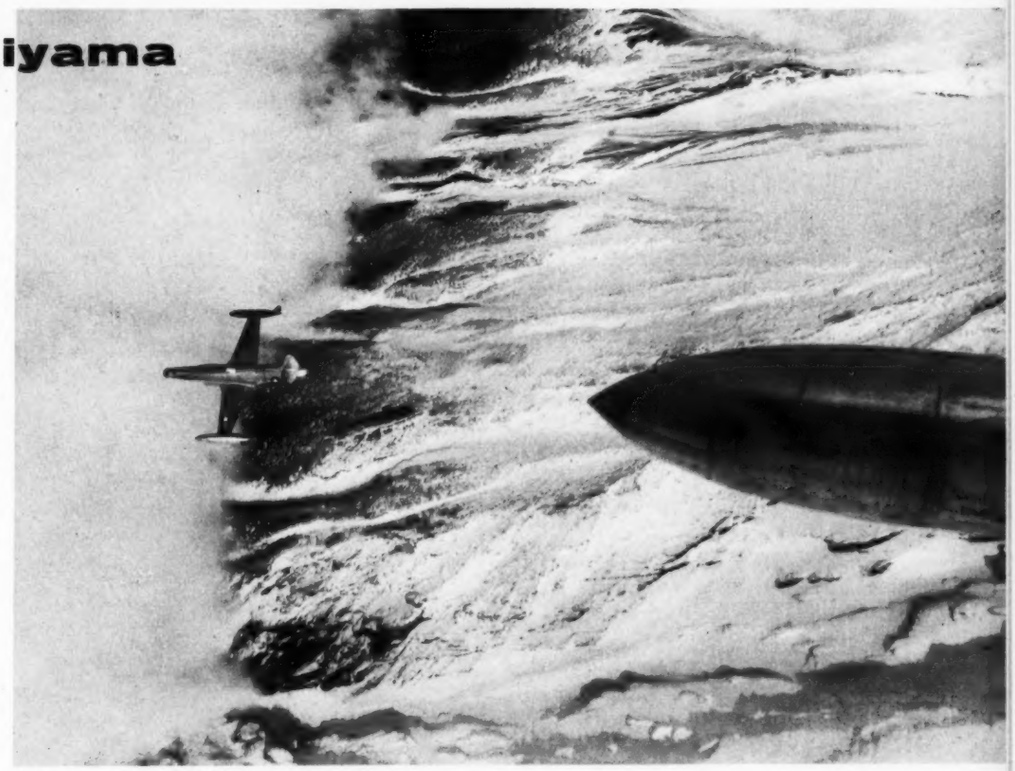


A Lockheed F-94 A "Starfire" flying over the slopes of Fujiyama.

Flying over Fujiyama

Fujiyama, or Mount Fuji, rising towards the sky southwest of Tokyo, no doubt is among the most famous mountains in the world. Also known as Fujinoyama or Jujisan, Japan's mystery mountain is 12,400 feet high and the country's second-highest peak. Its symmetrical cone has long been one of the most popular subjects of Japanese painters and poets, and today it is the rendez-vous of tens of thousands of Buddhist pilgrims and European mountain climbers a year. On July 10th of every year, the Japanese celebrate the "mountain inauguration festival," and on September 3rd or 10th the generally snow-free climbing season ends. Climbing Fujiyama has not always been very safe, since the mountain was long known as one of the most active volcanoes. Its last eruption is reported to have taken place in 1707 or 1708. Depth of the crater is about 550 feet, diameter about 1,400 feet.

Since the end of the war, Fujiyama has had to give up its innermost secrets to the prying eyes of members of the U.S. Far East Air Force. The pictures on this page give a bird's eye view of Mount Fuji and the surrounding wilderness.



The snowscape surrounding Japan's "holy mountain."

Lockheed F-80 "Shooting Star" fighters of the USAF's Japan Defense Force above the peak of Fujiyama.

German Aviation on the Way

Anyone with an even superficial acquaintance with the personalities of international aviation who entered the lobby of the Hotel Excelsior, Cologne, at the beginning of March 1953 would have been impressed in spite of himself. A gathering of notables from throughout the world : Leonard Schwartz, Vice-President and General Sales Manager of Lockheed, accompanied by his European representative Ed Fife ; a few tables away, Jim Lee, his colleague from United Aircraft Export Corporation, with the latter's newly-appointed German agent, Igor Sikorsky Jr. The visitor might also have met Mike Oliveau of Douglas or Consolidated Vultee's representative. Not far from Cologne, say between Bonn and Heidelberg, he'd have come upon the President of Curtiss-Wright or Republic Aviation Corporation driving busily along the Autobahn. Then in the hotel bar he was sure to meet not only Frenchmen and Italians, but also a number of important-looking Englishmen connected more or less closely with Rolls-Royce, de Havilland's or Vickers-Armstrongs.

Quite a gathering, and the reader will understandably ask what it is all about. Firstly it is about :

Air transportation

Let us refresh our memories a little. In the spring of 1951 it seemed to Federal Transport Minister Dr. Hans Christoph Seebohm that the time had come when he could use the word air transportation not just as an electioneering catch-phrase, but as a demand to the outside world, almost as an existing fact. He formed an aviation section under his Ministry and gathered about him men such as Dr. Knipfer, Kreipe and Hübner, who seemed to offer every guarantee of a resuscitation of German aviation and the creation of a new "Deutsche Lufthansa." These officials from Bonn formed a kind of private office in nearby Cologne to which they gave the name "Büro Bongers." Its head, Hans M. Bongers, a former official of the Lufthansa, was the man who brought the most substantial expert knowledge with him.

At this time it was rumoured persistently that some of the top men from foreign air transport companies were becoming frequent visitors to the new Bongers office on the banks of the Rhine, but Bonn professed to know nothing about it. Herr Bongers ? Scarcely known by name. Dr. Plesman of KLM or Ralph S. Damon of TWA ? Excellent gentlemen no doubt, but officially quite unknown in Bonn. These visitors were received by the non-official Herr Bongers. Such was the prelude.

Things began to get more serious when it was decided in Government circles on January 6th, 1953, to make the Bongers office into a preparatory company for a new German Lufthansa, under the name *AG für Luftverkehrsbedarf*. The new company's directors and management included a number of highly respected names. Chairman of the Board is Dr. Kurt Weigelt, former President of the old Lufthansa, with international connections. His deputy is Dr. Knipfer, head of the Aviation Section of the Federal Transport Ministry in Bonn, an energetic, somewhat ambitious man. Then there is Professor Frohne, a former Under Secretary of State and a close friend of the Federal Transport Minister's ; a former Luftwaffe general, Werner Kreipe, a political associate of the Minister's ; and a number of men more directly concerned, such as Prof. Heinz Oeftering of the Federal Finance Ministry, Ministerial Director Leo Brandt representing North Rhine-Westphalia and Dr. Klett, Lord Mayor of Stuttgart. It would be betraying no secret to say that Dr. Knipfer and his men from the Federal Transport Ministry tried from the very beginning to keep the reins in their own hands. The management and board of directors of the *AG für Luftverkehrsbedarf,* however, also includes men like Hans M. Bongers, of the old Lufthansa, as head of a future executive body, Engineer Hoeltje, responsible for technical questions, and the lawyer Walter Issel.

Just before the foundation of the *AG für Luftverkehrsbedarf,* there was, however, a brief interlude, the significance of which was apparent only to the initiated. The President of the West German Federal Republic had conferred on Juan Terry Trippe, President of Pan American World Airways, a high order of merit "for services in the reconstruction of Germany." PAA's participation in the Berlin airlift was cited as Trippe's contribution to German reconstruction, but here surely he was being given credit due to General Lucius D. Clay, who was really responsible, with the U.S. Air Force, the Royal Air Force, the French Air Force and with chartered aircraft from many airlines, for preventing Berlin from becoming Russian overnight. The German man in the street was doubtless impressed when Mr. Trippe received his award, and certain foreign quarters certainly pricked up their ears. Mr. Trippe had shown himself to be very "accommodating" towards the old Lufthansa when, shortly after the outbreak of war, he had "Pan-Americanized" the Lufthansa branches in Central and South America. But how should the experts at Bonn's Ministry of Transport know this ?

Mr. Trippe went off with his medal and continued with his reconstruction work. He offered the *AG für Luftverkehrsbedarf* some Convair 240s which had been operating for years in the Caribbean and were ready to be honourably pensioned off. He didn't even ask cash for them either but a few first-class German hotels to round off his *International Hotels Corporation.* For long-range operations he recommended the purchase of four-engined Douglas DC-6Bs, which he himself had ordered in quantity. He also promised every assistance to the future German airline, and up to the end of February 1953, it looked as if Mr. Trippe's suggestions had fallen on fruitful ground.

Suddenly a chill fell over the proceedings. The representatives of the Federal Finance Ministry and of the provincial governments found the price for a few outdated Convair 240s a little exaggerated. And at a meeting of the Board of Directors of the *AG für Luftverkehrsbedarf,* Dr. Knipfer's ministerial group found itself in the minority, and Mr. Trippe received a polite but unexpected refusal.

At this meeting of considerable importance to the future of German air transport, something like the following decisions were taken : no second-hand aircraft, but only brand-new ones of a type that has already proved its worth ; no very large fleet to start with, therefore not thirty aircraft, but a maximum of twenty, so as to keep one's hands free in case turbine aircraft should turn out within the next few years to be a

practical proposition. That is to say, no more or less untried British turbine aircraft, but proved American equipment. Convair 340s (not 240s) for short and medium stages, and four-engined Douglas DC-6Bs.

As soon as these decisions became known, all who were interested in the matter streamed together at Cologne's Excelsior Hotel. It was not so much for the twenty aircraft as a desire to figure as supplier on the books of "Deutsche Lufthansa 1954."

On the German side it has already been definitely announced that a new German Lufthansa will enter the European air transport arena in the spring of 1954. However, it will only be able to cope with 50% of the domestic German traffic volume to begin with. This is quite logical, since the German treaty gives the airlines now operating to Germany something like a year's grace after the beginning of German operations. Then—unless a miracle occurs—the German airline will not be permitted to fly to Berlin for an indefinite time. But the modest share of 50% in German traffic will doubtless soon increase. Today, foreign airlines can operate to a large number of German cities, but whether they will be able to do so tomorrow, without granting similar rights in return, is another question. Here too, the rejection of PAA's proposals is indicative of a desire for complete independence.

All this would seem to indicate that plans for the Deutsche Lufthansa are now well on the way. Bongers and Hoeltje of the *AG für Luftverkehrsbedarf* and the well-known expert von Engel are already well thought of abroad, and there are other experts in reserve.

However, the future development of the Aviation Section under the Bonn Federal Transport Ministry is not quite so clear. Admittedly Knipfer and Kreipe have been appointed to the management of the *AG für Luftverkehrsbedarf,* but their names still do not figure on the list of permanent officials at the Transport Ministry. If one is to believe German press reports and the reports of occasional German correspondents, there was recently a small incident which throws considerable light on the whole situation. In order to get more funds for the embryonic German airline, a memorandum was submitted to the transport committee of the Bonn Parliament, with an appendix giving a historical outline of the development of the old Lufthansa. This appendix was an almost word-for-word copy of parts of a history published by the Lufthansa in 1936, at the height of the Nazi régime. Had the Bonn editor no time to check the 1936 document or . . . had the phrases of those days become part of his flesh and blood ? Whatever may be the answer, the West German Federal Republic received in 1953 a document which contained hymns of praise for Hermann Göring, Adolf Hitler and the Thousand-Year Reich. Parliament looked somewhat askance and protested. The memorandum had to be withdrawn, the meeting was adjourned and the Transport Minister was asked for an explanation. To do him justice, the latter unequivocally condemned the offending passages.

Yet, with or without such accidents, German air transport is on the way. The question of participation by the Länder (other than North Rhine-Westphalia) and of private enterprise in the AG für Luftverkehrsbedarf and later in the new Lufthansa is still open. Very little about this has been heard of late. However, it may be assumed that nobody wants a purely Government-controlled airline, and that efforts towards creating a broader basis will continue.

The German air force

Basically, the reconstitution of a German air force, even if at first it is only a tactical force, is much more important than that of a German airline. An airline may more easily capture the public imagination, but the creation of an air force is today much more valuable from the industrial point of view.

Now this is a subject which should be discussed with all caution, not because it is a politically delicate one—what subject is not a delicate one these days ?—but because decisions may be taken during the next few weeks, perhaps even before these lines appear in print, which will give the lie to all forecasts. It is most likely, for example, that the German treaty and the agreements on the European Defence Community will finally be ratified after the visits of French Premier René Mayer and Federal Chancellor Dr. Konrad Adenauer to Washington. The date of their ratification, however, will depend on domestic politics on either side of the Rhine. Perhaps not till autumn, perhaps earlier. The ratification will also determine the date for establishing the first cadres of a new German air force. If for example, some date in the spring of 1954 is fixed for the resumption of German air transport, the same date may also be chosen for the air force.

There is no room within this brief survey to go into all reserves still made today by the French in relation to the plan, originally of French conception, for the European Defence Community. However, Articles 106 and 107 of the text of the EDC treaty are particularly significant. If applied literally, the agreement could greatly reduce or even cripple all French research and production. An armament commissioner, of as yet undecided nationality, could forbid all munitions production, from powder to aircraft. We feel here the hand of a legislator who was not too intimately acquainted with technical matters, particularly as he completely overlooked the important "weapon of electronics."

To return to Germany : two figures seem to have been fixed under the agreement, namely 1,326 aircraft and 80,000 air force personnel, divided as follows :

10 wings of jet fighter-bombers of 75 aircraft each,
4 wings of 75 jet fighters,
2 wings of 36 all-weather jet fighters,
2 wings of 54 reconnaissance aircraft,
2 wings of 48 transport aircraft.
Total 1,326 aircraft, excluding trainers.

What is not yet known is the final choice for the senior officers, although the Blank Office—West Germany's future Defence Ministry—has already drawn up complete lists. A Parliamentary commission is to have a voice in this selection . . . a sensible precaution after the above-mentioned "Thousand-Year Reich" escapade.

Where will the aircraft come from for the new German air force ? To begin with, they will certainly not be of German design, and not even foreign models built under licence in Germany. Whether they will be American or British types has not yet been decided. French or Italian aircraft will doubtless be in the minority.

In any case it is quite understandable that France should protest against the ominous Articles 106 and 107, why British and Americans should be falling over each other in Bonn and Cologne.

* * *

The Impact of Cargo on Air Transport Planning

PAA wants a share of the cargo business

At the end of 1952, Lockheed Aircraft Corp., of Burbank, California, published a comprehensive study of the growth of air cargo in the United States and its future prospects. The report, entitled "Air Cargo Trends in the United States," is based partly on Lockheed's own investigations, and partly on statistic material supplied by the Civil Aeronautics Board and the major cargo-carrying airlines. The authors, L. R. Hackney and Charles Rausch, have arrived at a surprising prognostic: *air cargo, which at present accounts for about 20 percent of the operating revenue of the American domestic air carriers, will contribute no less than 37 percent of this revenue by 1958,* provided that new cargo aircraft now available are meanwhile placed into service.

This prediction may sound optimistic, but Hackney and Rausch support it with such precise, carefully evaluated facts and figures that the conclusion of the Lockheed report looks more than probable.

The American air cargo specialists are not the only ones to hold such opinions. In view of the extremely rapid growth of air cargo since the end of World War II, which has surprised even the most optimistic airline planners, a multitude of variations on the theme have become an almost regular feature of the financial reports of airlines all over the world. An idea of this growth, on a world scale, is provided by the International Civil Aviation Organization's report for 1952. It discloses that from 1947 to 1952 the various types of traffic in world airline operation increased as follows :

Passenger Miles	*Mail Ton-miles*	*Cargo Ton-miles*
109%	103%	233%

In other words, in six postwar years the percentage increase in cargo traffic volume was more than double the passenger traffic growth and, if airmail is included, more than three times the passenger traffic growth (it should be recalled incidentally, that passenger-miles and ton-miles are not comparable units of measurement).

The fact that this evolution has slowed down somewhat in the past two years is of no significance. In the long run, the steadily rising curve of air cargo traffic is bound to have substantial repercussions on operational planning and business policies in international air transportation. A prelude to this development may be seen in the proposal put forward by Pan American Airways a few weeks ago to introduce substantial cuts in North Atlantic cargo rates. The company's Vice-President for Traffic and Sales, Willis G. Lipscomb, suddenly announced to an unprepared aviation world that PAA was determined to lower North Atlantic cargo rates by 45 percent as from November 1953—from $0.64 to $0.35 per ton-mile. And he added that PAA would not mind running the risk of encountering opposition from other North Atlantic operators belonging to the International Air Transport Association.

Pan American Airways has thus brought heavy artillery into the line, which is proof that its own estimates of the situation coincide with Lockheed's prognostic. Adapted as it is to the distances involved in transoceanic air travel, the Atlantic cargo rate envisaged by Pan American is still considerably higher than the rate in force for the U.S. domestic services, which in June 1948 was fixed by the CAB at a minimum level of $0.13 per ton-mile. But even so it will be possible after November 1953 to send a consignment of 500 kg or more from New York to London at a cost of only $1.32 per kg, instead of $2.42 as at present.

If the other IATA members fail to adopt PAA's suggestion, then a wide-open rate war is absolutely on the cards.

The case of PAA is only one arbitrary example of the possible effects of the cargo boom on air transport planning. In principle, however, every thinking airline executive will study the practical repercussions of the unforeseen upswing of cargo traffic. It is not necessary to explain that this growth must have a major effect on equipment, personnel and route planning. It will be of great importance whether passenger versus cargo operations will show a ratio of eight to two or whether they will reach a proportion of six to four in the relatively near future. To express it drastically : must the airlines continue to "chase" after the passenger, i.e., must they make available ever faster first- and second-class aircraft, or should they gradually change over to the fat-bellied freighter, flying at more leisurely speeds ?

A Douglas DC-6A "*Liftmaster*" loading a jeep by means of a platform moving along two vertical rails.

1918 . . . Visions of air cargo

A great portion of all theoretical and practical work in aviation centres, directly or indirectly, around the performance which is demanded from an aircraft. In addition to serious technical and scientific contributions to this subject, one frequently encounters fantasies from the pen of "go-getters" who refuse to admit that the aircraft in its present form has any title to existence at all, simply because the work it performs is claimed to be out of proportion to the energy involved. Thus, a recent article *

* « *Das Geschwindigkeitsideal in der zivilen Luftfahrt* » by Wolf Loah. International Transport Archives, Mainz, Germany.

takes as its starting point a performance comparison for several modes of transport, opposing the "results" achieved in the form of payload, speed and range to the power required in each case :

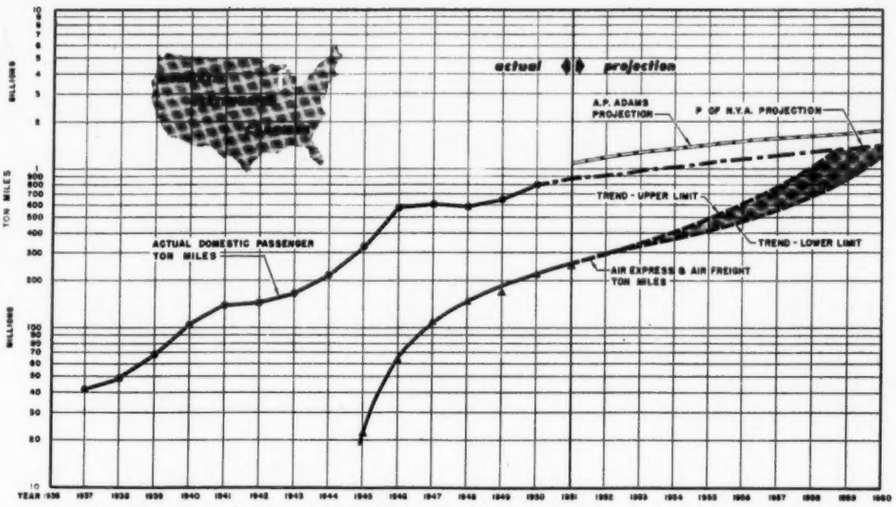
	Aircraft	*Truck*	*Rail*	*Shipping*
Power	10,000	100	1,000	5,000
Payload (tonnes)	5	15	300	10,000
Speed (km/h)	500	40	40	25
Range (km)	6,000	500	500	6,000

On the basis of this compilation, the writer then allocates the following "transport coefficients" to the individual modes of transport : aircraft 1, truck 2, rail 4, shipping 200. From which he draws the somewhat nebulous conclusion that the aircraft is not much good . . .

Well, one can hardly blame the aircraft for these figures. In reality they merely illustrate the platitude that the 350 to 400 m.p.h. flying speeds of modern air transport must be paid for. Were this speed not worth its price, it would be difficult to understand why businessmen all over the world stubbornly continue to entrust their goods to the aircraft.

The serious complex of problems represented by "payload-speed-range" or, expressed differently, "passenger service-cargo service," should not be dismissed lightly. Yet attempts to solve such questions should be carried out more carefully. The methods used by a group of men who sat down at a conference table thirty-five years ago to look into the future of civil aviation might even be adopted.

In the last year of World War I, the British Air Board charged the Civil Aerial Transport Committee with the task of studying "what steps should be taken with a view to the development and regulation of aviation for civil and commercial purposes from a domestic, and imperial, and an international standpoint." (Although this is not mentioned in the official documents, the Air Board's directive is said to have stipulated that a prognostic valid for about three decades should be made ; *"Airways Abroad," H. L. Smith.—The University of Wisconsin Press, 1950).* The Committee's 83-page report was published by the British Government in 1918 ; among other signatories were : Major-General W. S. Brancker, General E. M. Maitland, G. D. Siddeley, T. Sopwith, G. Holt-Thomas. The fact that the famous "futuristic philosopher" and writer of Utopian novels, H. D. Wells, belonged to the committee as chairman of the subcommittee for labour and social questions does not seem to have a detrimental effect on the experts' realistic approach. In any case, the meetings of this committee produced a report whose conclusions, in spite of a total lack of practical experience and the absence of suitable transport aircraft, are of great interest even today. Performance-wise, the report chiefly discusses the "speed versus payload" question :



In order to obtain a direct comparison of the probable growth of passenger and cargo traffic in air transportation, the cargo analysts of Lockheed converted passenger-miles into passenger-ton-miles. According to data furnished by the Port of New York Authority, the curves of the two traffic categories will meet in 1960. In other words, passenger and cargo traffic volume will reach an equilibrium at that time.

" . . . High load and speed are antagonistic elements in the problem. To secure high speed, the commercial load must be kept within narrow limits. From the figures submitted to us, it would appear not to exceed 25 per cent of the total loaded weight of an aeroplane."

What conclusions did the authors draw regarding the potentialities of air cargo transport ?

" . . . It is more difficult to settle the reasonable expectation of general goods traffic, which must take the form of express parcels, usually of small weight. Furs, lace, jewels, precious metal, extracts, essences, valuable feathers, etc., might be carried by air because of their high value ; also rare and out-of-season fruits and vegetables, flowers, and perishable articles generally, newspapers and periodicals afford scope for aerial services, because news grows stale quickly. Drugs, dyes, chemicals, medicines, optical and surgical and other instruments will be so carried, as often these are wanted quickly. Wherever, for want of some article, life is endangered or industry is at a standstill, as where some spare part or tool is required for a machine, the aeroplane will afford a quick remedy, and its flight will be profitable. Cinematograph films, gramophone records and commercial samples may figure in the class of goods carried by aircraft. Their rapid distribution will quicken exchange, and this will react to increase the volume of traffic, but the whole series of illustrations above given tends only to show how limited the total volume or weight of aerial goods traffic is likely to be in developed countries."

Put down on paper in 1918, this "cargo manifest" remained valid without restriction until World War II. The British Air Board will hardly have appreciated at the time how thorough had been the work of its Civil Aerial Transport Committee, all the more so because the members of the Committee had to base their investigations and conclusions on only five rickety (by today's standards) aircraft types which certainly did not yield an enormous amount of valid information. They were the Handley Page transport powered with two 250 h.p. Rolls-Royce engines, the "America" flying-boat, the de Havilland D.H. 4 powered with a 250 h.p. Rolls-Royce engine or a "BHP" engine of 230 h.p., the "R.E." with a 150 h.p. air-cooled RAF engine, and the Sopwith "Pup" powered with an 80 h.p. Le Rhône engine. That was all.

Thirty-five years later

It would be easy to print one of those famous "queer cargo" stories which periodically make their appearance in the daily press, complete with pictures of bulldozers, ship's propellers and hippopotami . . . But of greater interest is a brief glance at the conclusions which the air transport industry will inevitably have to draw from the present situation.

That the fundamental problem is unchanged, with the exception of a few details, is revealed in the 1952 report by Sir William P. Hildred, Director-General of the International Air Transport Association. He bases his views on the future of the new tourist-class services on the following considerations :

Competition of surface transportation is particularly heavy in Europe, where on numerous routes *rail travel is equally rapid* if the regrettable waste of time still involved in air transportation is taken into account (city to airport transportation, customs and passport formalities). Three courses are open to improve air transport economy : reduction of aircraft weight, for example by the use of lighter seats ; reduction of free baggage allowances ; increase of payload by reducing the fuel supply, necessitating more intermediate stops.

What proportion of the gross weight is occupied by payload today? In 1918 the Aerial Transport Committee estimated a maximum payload of 25%, as stated above.

Data supplied by the manufacturers show the following payload figures for some of the most widely used—or ordered—modern aircraft types:

Payload percentages of gross weight
(approximate)

Twin-engined types	
Convair-Liner 240	about 25%
Convair-Liner 340	about 27%
Martin 4-0-4	about 25%
Four-engined-types	
Douglas DC-6B	about 20-25% (overseas and continental services respectively)
Douglas DC-6A *Liftmaster* (cargo version)	26% for overseas about 30% or more for continental services
Lockheed L-1049C *Super Constellation* (compound engines)	about 20-25% (overseas and continental services respectively)
Lockheed L-1049B *Super Constellation* (cargo version)	about 25% overseas about 30% and more for continental services
Blackburn *Universal Freighter*	32%
Bréguet 763 *Deux Ponts*	about 22%
Propeller Turbines	
Vickers *Viscount 701*	20%
Bristol *Britannia*	18%
Jet-Propelled Transports	
D.H. *Comet 1A*	about 8%
D.H. *Comet 2*	about 12%
D.H. *Comet 3*	about 12%

A cursory glance at this table might convey the impression that modern transports are not doing any better than those of 1918. Naturally, this would be an obvious fallacy, since the British Committee of 1918 estimated maximum future ranges of 350 to 500 miles, roughly the distance between London and Geneva. Modern transports carry their loads 2,000 or 2,500 miles across the oceans, which necessarily entails heavy fuel loads. Thirty-five years ago flights were made at low altitudes at speeds not exceeding 80 m.p.h., today piston-engine aircraft travel at 15,000 to 20,000 feet at speeds of 300 to 400 m.p.h. and jet transports at 35,000 to 40,000 feet at speeds of 500 to 530 m.p.h.

In reality, the capacity of transport aircraft has grown in a degree which would not have been conceivable a mere 10 years ago. But the above table discloses another noteworthy detail. Certain aircraft types, such as the Douglas DC-6A *Liftmaster*, the Lockheed L-1049 B *Super Constellation* and the Blackburn *Universal Freighter* indicate a trend towards greater payload shares in the gross weight. In other words, the specialized "cargo aircraft" is beginning to emerge. So far this is merely a beginning, since most of the present "cargo aircraft" are nothing but special versions of large passenger transports with performance characteristics—chiefly speed—virtually identical to those of the passenger types.

This should now be the point for certain studies which can be only outlined here, since they must remain speculative until the manufacturers and airline planners have reached tangible results. It cannot be stated, for instance, whether a division of the air fleets into cargo and passenger units beyond the extent practised today would result in economic benefits; or whether the development of rugged, simple, cheap cargo aircraft, the range of which would be adapted to certain typical trunk cargo routes and which would fly at economically low speeds, would be recommendable. The statistical material indispensable for such decisions is still largely unavailable. Certain technical and economic aspects of the problem were outlined on May 5th, 1951, by Sir Frederick Handley Page—who did not deal specifically with air cargo—in the Third Louis Blériot Lecture to France's *Association des Ingénieurs et Techniciens de l'Aéronautique*.

One may question whether the time is ripe for the pure cargo aircraft. But that it will come one day is beyond doubt, in spite of all the conservative arguments to the contrary.

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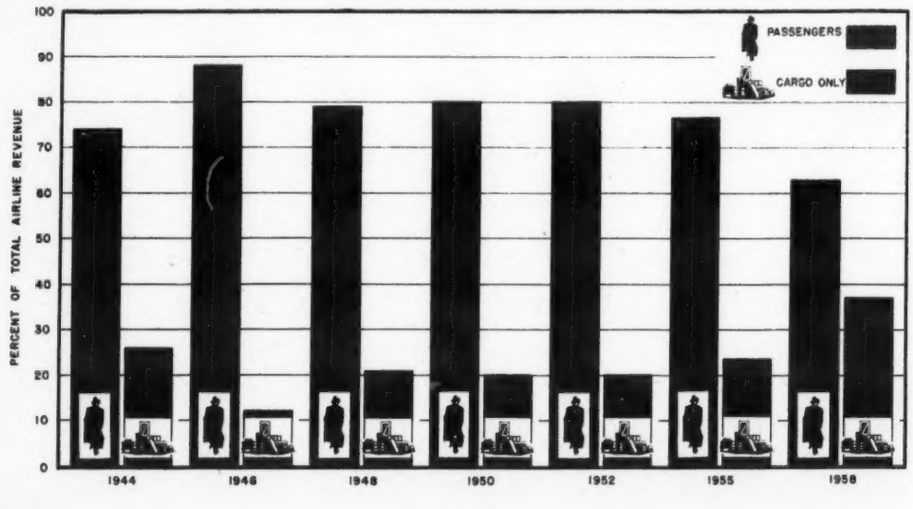
So much for the future cargo transport equipment. On the organizational side of the air cargo business, one might raise the theoretical question whether or not cargo carriage should be left to specialized carriers in a greater measure than it is today.

It is obvious that the U.S. Civil Aeronautics Board has rejected the idea. The CAB has been extremely reluctant in granting operating concessions to scheduled air cargo lines. The head of one cargo operator, Raymond A. Norden, President of Seaboard & Western Airlines, Inc., a large irregular carrier, specializing in Atlantic operations, complained bitterly about the CAB's attitude in an address to the Mariner's Club of New York on March 18th, 1953. He pointed out that his application for regular Atlantic cargo routes first filed with the CAB in July 1947 had not yet been acted upon, although "the American passenger carriers (i.e., PAA and TWA) presently certificated to operate on this route have been unwilling or unable to develop the freight business. Between 1949 and the end of 1952, the share of all-freight flights flown by U.S. certificated passenger carriers dropped from 81 percent to 30 percent. Conversely, it may be noted that the nations of Western Europe in particular have avidly pursued the freight business as a lucrative source of revenue. Thus, the share of all-freight flights made by foreign flag carriers increased from 19 percent in 1949 to 70 percent in 1952. In 1951, foreign flag carriers made a total of 339 trans-atlantic freight flights, compared with a total of only 9 by the U.S. certificated passenger carriers. Just a few weeks ago, the British Government recognized the need for trans-Atlantic freight services by granting a licence to Airwork Ltd., an independent carrier, to operate between London, Canada and the U.S. in competition with the Government-owned British Overseas Airways Corporation. By way of contrast, this licence was granted less than five months after the carrier had filed its application . . ."

The Civil Aeronautics Board's apprehensions of a possible "cargo monopoly" in the hands

According to figures estimated by the air cargo experts of Lockheed Aircraft Corp., the share of air cargo in the total revenue of American domestic air transportation will rise from 20 percent in 1952 to 37 percent in 1958. (The diagram does not take into account the passenger revenue of irregular carriers, nor their cargo revenue since 1949.)



of a few specialized carriers are understandable. The CAB probably still shudders when it recalls the events of the immediate post-World War II period, in the course of which the American air cargo business saw the light of day and threatened to disrupt the entire American air transport system. Like mushrooms, countless cargo-carrying companies, operating surplus Air Force transports flown by ex-military pilots, appeared on the American scene—to vanish again shortly afterwards as a result of fierce cut-throat competition. Behind them they left a trail of bankruptcies which was not always pleasant to contemplate.

Four scheduled cargo lines are today operating in the U.S., Slick Airways Inc., Flying Tiger Line Inc., U.S. Air Lines Inc., and Riddle Aviation Co. The first three run domestic services, the fourth flies between New York and Puerto Rico.

On the whole, the economic situation of these companies is satisfactory, but U.S. Air Lines was recently faced with a financial crisis and subsequently was reorganized. Nevertheless, the two largest of the four, Slick and Tiger, announced a few weeks ago that they have decided to merge for reasons of economy. Among the irregular carriers, Seaboard & Western seems to be the financially soundest operation (net profit: $215,288 in 1950; $518,015 in 1951; $567,980 in 1952).

A modern folding container, designed for air cargo use by the *Société d'Exploitation de Containers*, of Paris, in collaboration with the *Bréguet* aircraft company and *Aluminium Français*. The type has now been available for several weeks. It weighs 150 pounds empty and can accommodate a weight of one ton; its useful volume is 1 cubic metre.

It is a historical fact that the original tempestuous growth of the air cargo business was triggered by the irregular carriers who, as is known, initially were instrumental also in the introduction of tourist-class passenger fares. But it would be wrong to deduce that air cargo should in future be carried by specialized freight carriers. No doubt the cargo business, once it has reached its full development, will form the cornerstone of the profit and loss accounts of the scheduled carriers, just as freight business today plays a predominant role in rail transportation.

It must never be forgotten that in spite of its astounding growth, air cargo is still very much in its infancy. Measured by the yardstick of surface cargo transport, U.S. air cargo carriage of 1950 amounted to only 0.0626 percent of the entire American cargo volume. Even if its volume should reach 1,000,000,000 ton-miles by 1958, as the Lockheed report predicts, it would still amount to only one-third of one percent of the surface cargo volume. All this will change, however. Without any doubt, air cargo will conquer new commodities in the course of the coming years. While cement and bricks will hardly ever disappear into the holds of cargo aircraft in normal times, there is virtually no limit to the cargo manifests of the airline companies today—though they will exclude very low-cost bulk commodities. As in the passenger air travel business, the future of air cargo lies in mass transportation. And the necessary volume of goods will be forthcoming in the next few years.

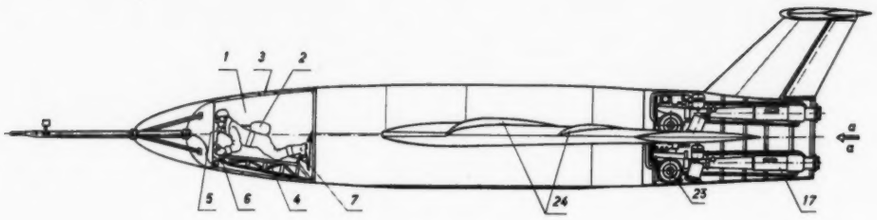
Pioneer's New Personnel Parachute

Pioneer Parachute Company of Manchester, Conn., reports that it has acquired production and sales rights to a new type of life-saving parachute with "guide extensions," known as the "Personnel Guide Surface Parachute." The new parachute was developed by *Dr. H. G. Heinrich* at Wright Air Development Center, Dayton, Ohio, and has been tested in over a thousand live jumps and dummy drops at speeds of up to 410 m.p.h. It offers the following advantages:

1. reduced opening shock, particularly at higher speeds of flight;
2. rate of descent of 19.6 feet per second, instead of the usual 25 feet per second;
3. high stability and absence of oscillations.

These advantages are due to the parachute's guide extensions, elliptical shaped flaps sewn to every second gore in the canopy. The flaps form an angle of 45° to the line of descent during a jump and produce an air deflection and a high rate of drag. Some of the braking effect is felt even before the canopy is fully opened, thus reducing opening shock.

A brilliant future is forecast for the new equipment, especially when it is used in conjunction with ejector seats in high-speed aircraft. There is also talk of civilian use—weight could eventually be reduced because of the lower stress on the fabric panels and the ropes. The parachute is expected to go into production shortly.

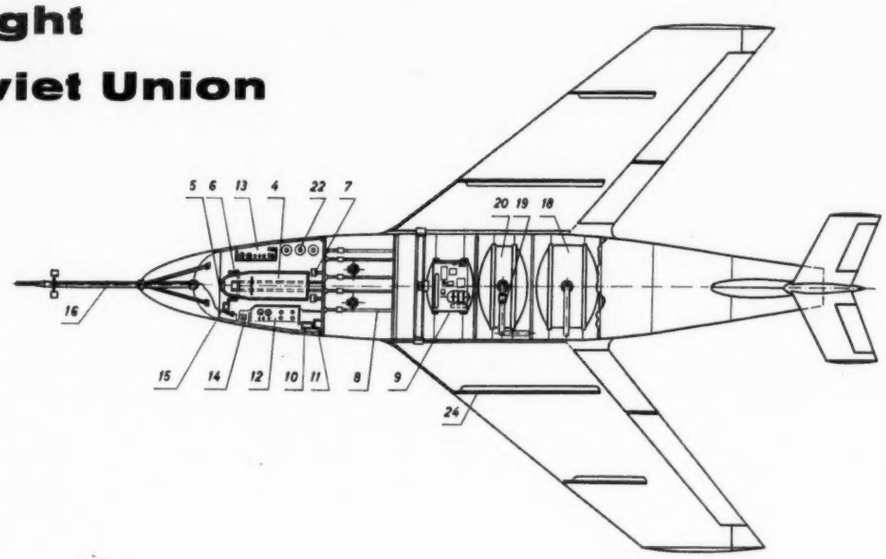


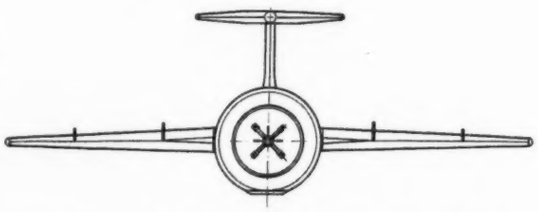
Supersonic Flight in the Soviet Union

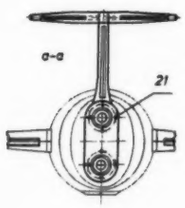
Russia has to a certain extent a group of American Army officers to thank for her first rocket-powered supersonic aeroplane, the "top secret" *DFS 346 research aircraft,* designed by the Deutsche Forschungsanstalt für Segelflug, and counterpart of the American experimental types Bell X-1, Bell X-2, Douglas *Skyrocket* and Douglas X-3. At the time of the German capitulation the DFS 346 was in final assembly at the Siebel works, Halle.

During the first few weeks after the war, Halle was occupied by the Americans, and it was not until later that the Russians moved into Saxony according to plan. The local American commander apparently had no misgivings at handing over the whole Siebel factory, lock, stock and barrel, including research division and prototypes. The whole staff, from the chief designer (Engineer Heinson) and test pilot (Ziese) down to the humblest cleaning woman, was summoned to the factory yard. A brief salute . . . and the Russians took over and began working immediately in three shifts.

Russian engineers soon realized what prize had so unexpectedly fallen into their laps. A prototype, based on flight and operational experiments in Lippisch's rocket fighter (Messerschmitt Me 163), was then under development, which with two of the same "hot" Walter engines* promised to reach supersonic

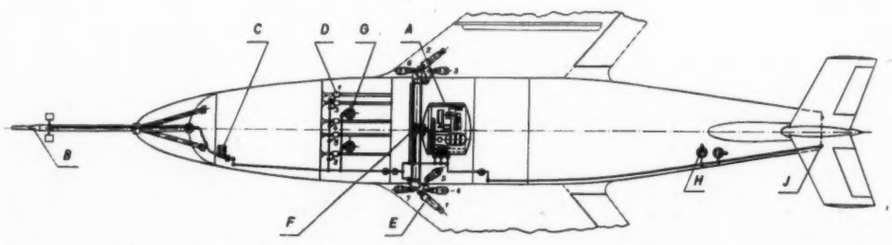






Three-view drawing of the Germano-Russian DFS 346 rocket aircraft.

1. Pressure cabin
2. Pilot
3. Double wall
4. Pilot's bed
5. Chin support
6. Hand control levers
7. Foot controls
8. Control rods
9. Measuring centre
10. Transmitter
11. Receiver
12. Instrument panel
13. Instrument panel
14. Instrument panel
15. Quadruple pressure gauge
16. Pitot tube
17. Lower rocket engine
18. T-Stoff tank
19. Pressure regulator
20. C-Stoff tank
21. Thrust gauge
22. Oxygen tank
23. R.p.m. indicator
24. Boundary layer fence



The measuring installation in the DFS 346 consists of a pressure-tight centre (A) and a series of electrical measuring instruments. The centre contains a switch mechanism with drive, a 28-V transformer and accumulator; also three oscillographs and a number of amplifiers. Instruments for measuring angular velocity, angular acceleration, flying attitude about all three axes, and temperature, are mounted outside the casing. Measuring leads have pressure-tight connections.

A. Measuring centre and instruments (see above)
B. Combined measuring instrument for angle of attack and crabbing angle
C. Multiple pressure indicator
D. Control force gauge for elevator, rudder and aileron forces
E. Measuring instruments for wing forces (seven)
F. Measuring instrument for deformation of main spar
G. Gauges (four)
H. Gauge
J. Thrust gauge (four bolts each)

* Professor Walter's rocket engine (type designation 8-109.509; Walter K. G. Kiel) worked on two liquid propellants, which ignited spontaneously on meeting. These were the fuel, *C-Stoff* (Methanol and hydrazine hydrate) and the oxidizer, *T-Stoff* (concentrated hydrogen superoxide). The former also cooled the combustion chamber, and the latter was in part converted into high-pressure steam and used to drive the propellant pumps. The rocket thrust of the single nozzle could be regulated in steps between 440 and 3,740 lbs.; consumption: 4.2 kg/sec T-Stoff plus 1.2 kg/sec C-Stoff, per tonne thrust.

speeds. Its thin mid-set wing was swept back 40° from the c.p. line. To obviate possible stability disturbances in passing through the transonic range, a swept horizontal tailplane was fitted on top of the fin (the Me 163 did not have this). In addition to the rocket-powered all-metal prototype, an experimental wooden glider model, built to scale, was also under construction; it was designated *DFS 301*.

The Russians were so interested in continuing the German project that they decided in October 1946, when the work at Halle had reached a suitable stage, to move the whole factory to Russia immediately. Once more the whole staff had to parade—or rather they were dragged out of their beds by night, as witness the following extract from the diary of one of the men concerned:

"On October 22nd, 1946, at four o'clock in the morning, five soldiers with rifles, an interpreter and a Commissar came to my flat. We were in bed. The Russians pushed me aside as I opened the door and forced their way into the flat. My wife was shivering behind me in her nightgown, while the Commissar read out an announcement which the interpreter translated. It said that we were 'invited' to Russia for five years as 'guests of the Soviet Union.' Even before the Commissar had finished reading, the Red soldiers had begun to carry the furniture out of the house and to pack our clothing. Below there were trucks waiting with engines running . . ."

Destination was the Russian village of *Podberesye*, about 75 miles east of Moscow, where a "development combine" for former German aircraft workers (from Junkers, Siebel and Heinkel) was being formed. The combine was known as *OKB 2*.

When the prescribed operating altitude is reached the Boeing B-29 *Superfortress* "chartered" cheaply by the Red Air Force releases the DFS 346; both Walter rocket engines have been started.—(The picture is a reconstruction of a pick-a-back flight. It shows considerable resemblance to the series of pictures of the Douglas *Skyrocket* published in No. 10/1952.)

It was nearly six months before work on the DFS 346 could be continued. Towed and gliding tests in the engineless DFS 301 wooden prototype were not made until the late summer of 1947, when a Tupolev Tu-2 light twin-engined bomber was used as tug. Pilot Ziese, who flew the glider, was satisfied with the results.

The original prototype of the DFS 346 brought from Halle was now used only for strength tests, and a second experimental model with four boundary layer fences was built for flight tests. Its two Walter rockets burned for seven minutes, and it had extensive instrumentation. Work was constantly supervised by Russian engineers and repeatedly inspected by the top personalities in Russian aeronautical research, including designers Sergei A. Ilyushin and Andrei N. Tupolev. Heinkel's former project engineer, S. Günther, was also concerned in the work.

Flight testing began in the spring of 1948 at Toplistan airfield near Moscow (Podberesye has no airfield, but is connected by waterway with Moscow). The aircraft was carried by a bomber up to operating height, like the Douglas *Skyrocket*. The mother aircraft was a former Lease-Lend North American B-25 *Mitchell* twin-engined bomber. Later one of the three Boeing B-29 *Superfortresses* which had emergency landed near Vladivostok in 1945 was used.

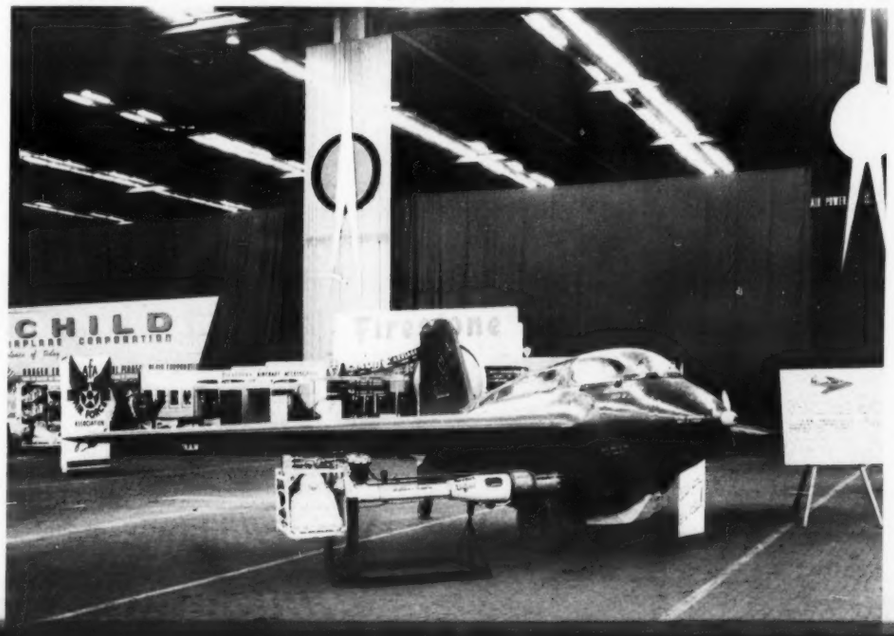
Except for violent vibration in the neighbourhood of the critical Mach number, the first flights were on the whole satisfactory. Pilots and engineers worked feverishly to correct the faults. In 1949 the B-29 was replaced by the Russian-built four-engined Tupolev Tu-4. At the same time German pilots in Russia, with the exception of Ziese, were grounded. Ziese was allowed to go on flying, because there was no Russian pilot willing to continue the flight testing.

Ziese managed to get through the critical Mach range on several diving flights. In the autumn of 1951 one of the wings failed at 65,000 ft. He stayed in the aircraft down to about 13,000 ft., then jettisoned the canopy and came down by parachute.

Since then prototype construction and flight testing have been transferred beyond the Urals. Some of the German staff were allowed to return to the Russian Zone of Germany. Our informant was one of these.

Siberia is as silent as the grave. What has since become of the Germano-Russian DFS 346 supersonic aircraft, or what may still become of it, only the future can tell . . .

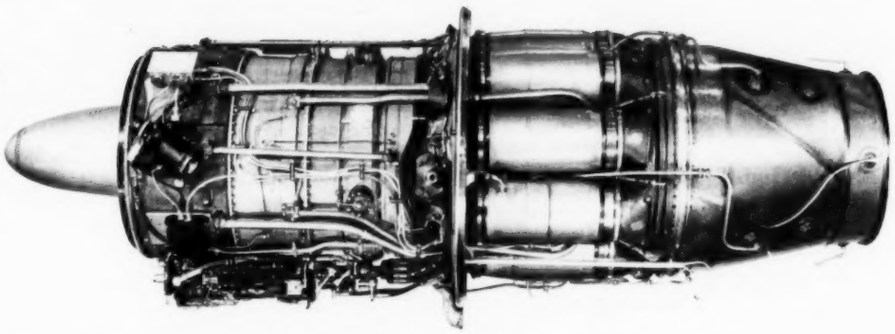
The predecessor of the DFS 346 was the Lippisch Me 163 subsonic rocket fighter (with no elevator unit). It had one Walter bi-propellant rocket engine of the same type (foreground).



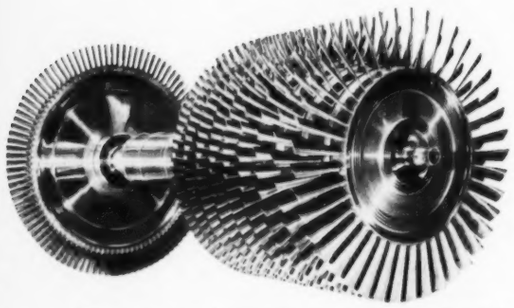
Jet Propulsion—a Small Nation's Dilemma

The story of Sweden's Dovern *jet engine*

Sweden—admittedly a highly industrialized country—is in the fortunate position among the smaller nations of having a well-developed aeronautical industry capable of producing military and civil aircraft as modern as anything in the world.

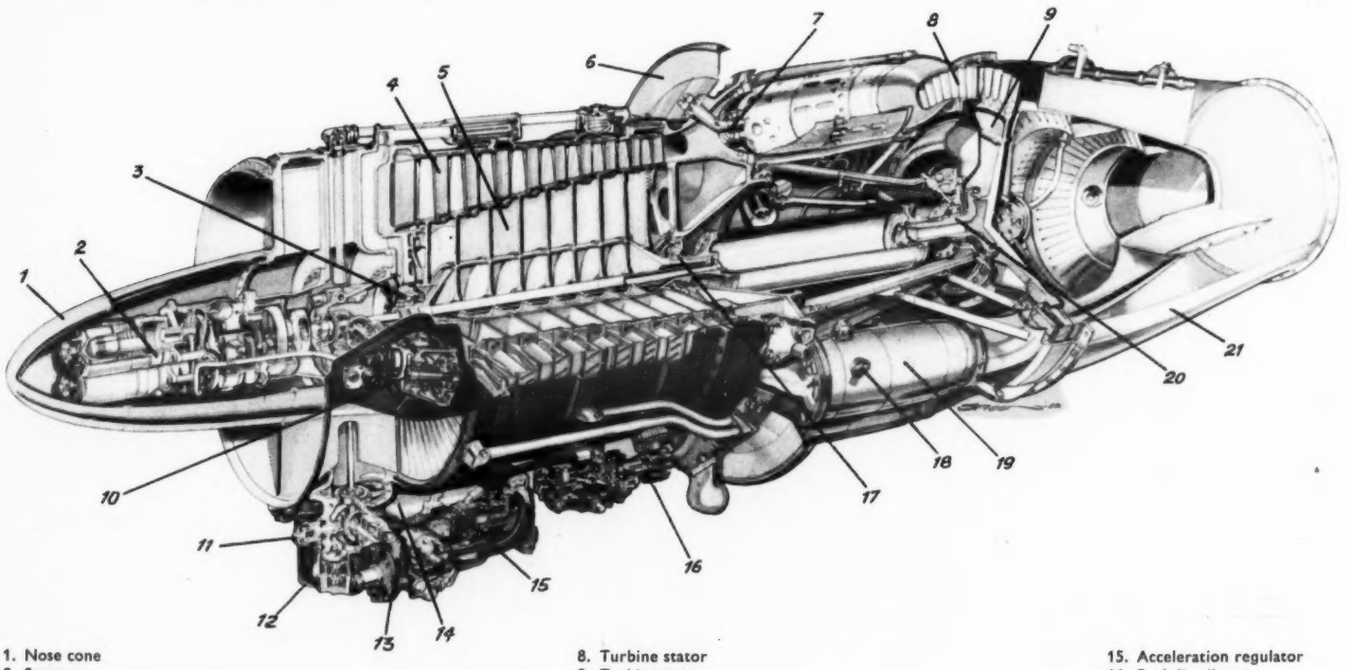


The STAL *Dovern II* axial-flow turbojet engine develops a static thrust of 7,200 lbs. at sea level.

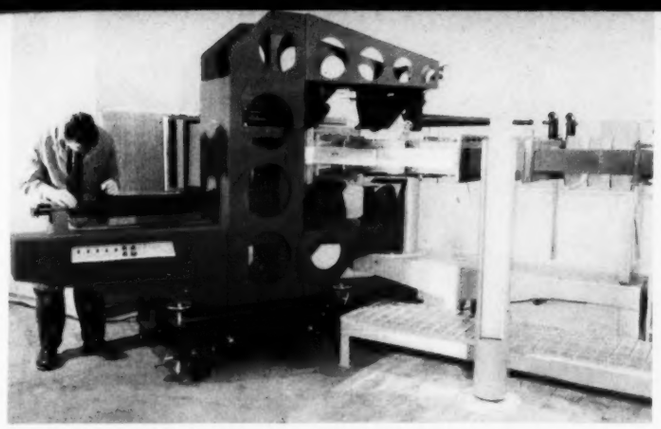


The rotor group (compressor rotor, wedge coupling and turbine wheel) is mounted on three bearings.

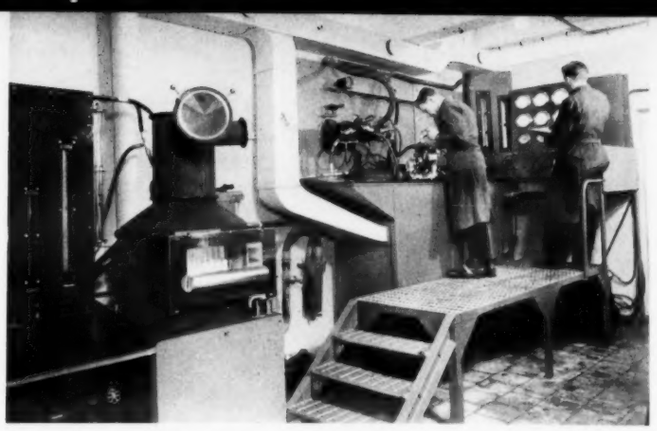
For aircraft engines, however, the country usually goes shopping abroad. Up to the present, Sweden's aircraft industry has relied almost exclusively on foreign aero engine designers, some of whose products have been built under licence. In 1944, however, first steps were taken to develop jet engines of national design. By the end of 1947 this effort had reached the stage of design work on two competing jet engines, one with radial



1. Nose cone
2. Starter
3. Forward compressor bearing
4. Compressor stator
5. Nine-stage compressor rotor
6. Fireproof bulkhead
7. Injection nozzle
8. Turbine stator
9. Turbine rotor
10. Auxiliary drive
11. Lubricant pressure pump
12. Oil filter
13. Fuel pump
14. Oil sump
15. Acceleration regulator
16. Fuel distributor
17. Rear compressor bearing
18. Igniter
19. Combustion chamber
20. Turbine bearing
21. Jet nozzle



Development of the *Dovern* was facilitated by STAL's modern equipment : a high-speed wind tunnel used for aerodynamic tests on the compressor and turbine blades.



Test equipment for fuel system.

compressor developed by Svenska Flygmotor AB, the traditional Swedish producer of foreign-licence engines, and the other with axial compressor by the *Svenska Turbinaktiebolaget Ljungström* (STAL), of Finspong, a centrifugal type project. It was not until the middle of 1949 that the *Dovern* was finally chosen for further development as the projected power plant for the new Saab-32 two-seat all-weather jet attack aircraft then being *Dovern* engine project and the conclusion of an agreement with Rolls-Royce Ltd. for the manufacture under licence of "an undisclosed version of the Rolls-Royce *Avon*" engine. On the basis of recent disclosures in Britain con-

Development of compressor blades : left, an early design ; right, one of the latest blades tested.

Development of flame tubes : left, early designs ; right, one of the latest models.

leading manufacturer of industrial turbines.

The axial jet engine reached the practical design stage in 1947-1948 and was named the STAL *Dovern*. It was based on the purely experimental *Skuten* axial-flow jet engine of 3,200 lbs. (1,450 kg) static thrust, which was built for the sole purpose of acquiring basic jet engine knowledge.

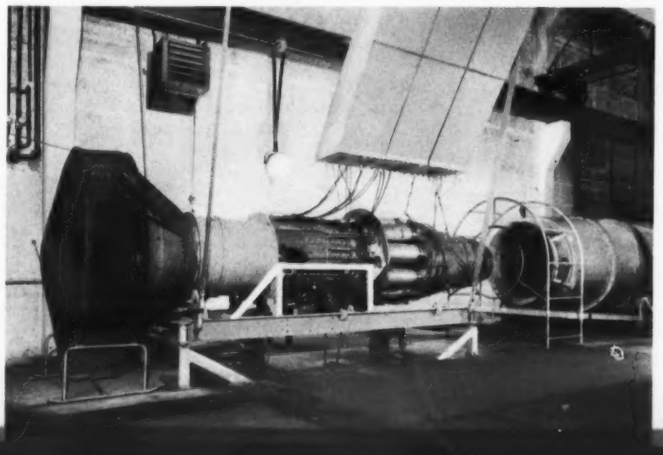
Initial *Dovern* development was somewhat hampered by competition for the necessary financial appropriations with the Flygmotor designed. At the end of 1950 STAL and Flygmotor joined forces on the engine, under the supervision of the Royal Swedish Air Force.

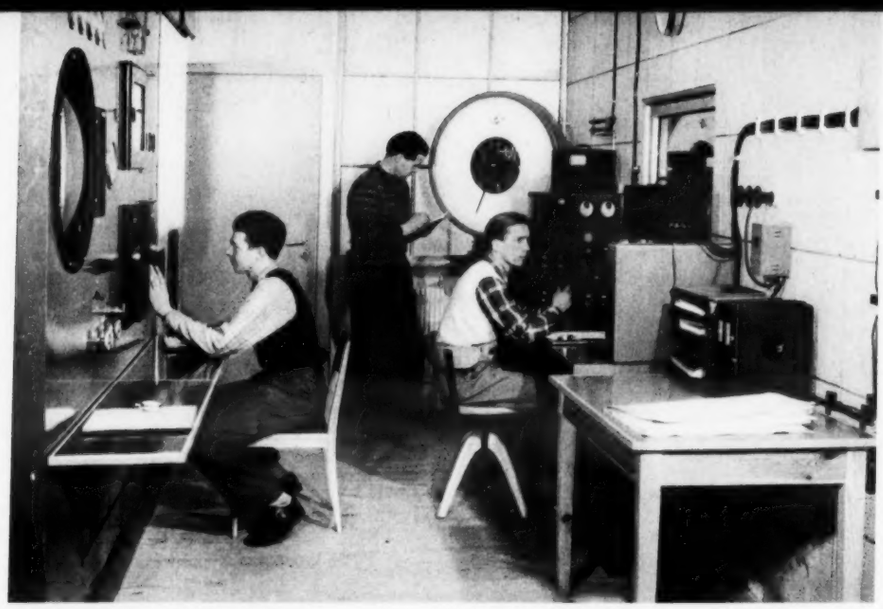
Thus it came as a surprise to everybody that the Saab-32 prototype was powered by a Rolls-Royce *Avon RA.2* engine of 6,000 lbs. (2,720 kg) static thrust when it made its first flight last November. The Royal Swedish Air Force subsequently issued a statement announcing the cancellation of the STAL cerning *Avon* development, this version appears to be the *RA.7* with re-heat (RA.7R) of 7,500 lbs. (3,400 kg) static thrust dry, and some 9,500 lbs. (4,300 kg) with re-heat.

The cancellation of the *Dovern,* which originally was specified for a static thrust of 6,600 lbs. (3,000 kg), and at the time of the cancellation was developing some 7,200 lbs. (3,300 kg) with the promise of even higher dry ratings, naturally caused a lot of comment in Swedish aviation circles. The critics said, with some

Glimpse of the assembly shop.

Engine test bed.





Control room of an engine test bed.

reason, that from a defence preparedness point of view it was unwise to make the country dependent again on a foreign supplier for engineering know-how, even if not for actual production. They seem to have been all the more justified by STAL's recent disclosure that the *Dovern* was ready to be put into quantity production.

The question arises, therefore, of why the Swedish Air Force decided to abandon the *Dovern* engine. This question has not been fully answered and probably will not be for some time for security reasons. It may be, however, that the cost incurred in developing the *Dovern* made the Air Force think at least twice before committing itself to any further expenditure on it or the even larger engines which were already under way. Some time ago it was reported that up to cancellation of the project, the *Dovern* had cost a total of nearly Kr. 20,000,000, but according to reliable sources the figure was actually much higher.

A leading part in the development work was played by *C. R. Nicolin*, chief designer of the *Dovern* and Vice-Chairman of the STAL works (centre), *Eric Oestmar*, Chief Engineer of the gas turbine development section (left) and *G. Stener*, head of the gas turbine test section.

STAL plant : in the foreground an engine test bed.

As mentioned above, the *Dovern* specification originally called for a static dry thrust of 6,600 lbs. (3,000 kg) with an optimum specific fuel consumption of 0.96 lbs./lb. thrust/hr. and a weight of 2,640 lbs. (1,200 kg). To what extent the *Dovern* actually met these requirements can be seen from the following type specification.

As was to be expected in a project of this kind, numerous technical difficulties were encountered. Initially designers were much troubled by compressor "surging," but through a series of modifications this was completely overcome. More than a hundred different compressor modifications were tested in the process. Combustion chambers also were the object of intense development, particularly with regard to their lifetime.

During the bench tests two serious failures occurred. One of these was a turbine blade break due to resonance vibration, the second a failure in the turbine bearing. The first problem was solved by a blade of more rigid design with only a slight increase in weight. Turbine bearing trouble was overcome by modifying cooling and lubrication.

Practically all vital parts of the engine were modified or improved at one time or another ; the total number of such changes ran into thousands, and ultimately all problems were solved. At this writing the *Dovern* has run more than 3,000 hours, about 130 of them in flight (under the belly of a *Lancaster* flying test bed).

Despite the *Dovern's* limited prospects in Sweden, the last chapter of its story has not yet been written, for STAL is continuing its development as a private venture with an eye on export.

The *Dovern,* however, was not the only project cancelled by the RSAF. An even more powerful STAL jet engine, known as the *Glan,* which by the middle of 1952 had reached the stage of component manufacture, was also affected. Of two-spool type, it was expected to develop a static dry thrust of 11,000 lbs. (5,000 kg) without afterburning. Whether work on this engine is continued will probably depend on how successful the *Dovern* is, either at home or abroad.

What's in the Air ? *

AVIATION POLITICS

United States bears 78 % of Western defence load

● Europeans who sometimes tend to feel exasperated by the United States' urging more rapid and effective defence measures should remember *what tremendous share of the total armament load America has herself shouldered.* According to figures published by Henri Vredenbruch, NATO's Deputy Secretary, expenditure by the various NATO powers during the 1952/53 accounts year (up to March 1st, 1953) was as follows :

USA	$49,500,000,000
Great Britain	$ 4,995,000,000
France	$ 4,047,000,000
Canada	$ 2,125,700,000
Italy	$ 996,500,000
Belgium	$ 483,800,000
Holland	$ 423,800,000
Turkey	$ 324,100,000
Greece	$ 206,200,000
Norway	$ 146,100,000
Denmark	$ 131,300,000
Portugal	$ 75,800,000
Luxembourg	$ 9,800,000
Total	$63,465,100,000

In other words, the United States bore 78% of the Western arms burden.

International Chamber of Commerce against revision of Warsaw Convention

● Many of the most important rules for carriage by air for hire or reward are based on the Warsaw Convention of 1929, which—originally signed by 37 States —was in the course of time ratified by 85 States, including Soviet Russia. For some time past efforts have been in progress to arrive at a revision of the Convention. In particular demands for an increase in the maximum compensation that can be obtained by an air transport customer from an air carrier have been made from many quarters, and a year ago the Legal Committee of the International Civil Aviation Organization submitted a draft of a new text. Now the *aviation committee of the International Chamber of Commerce (Paris) has pronounced against the proposed revision,* arguing that it is one of the best international agreements and has never led to any serious complaints in air transportation practice. Revision is not favoured because it is unlikely that a new convention could get the same number of ratifications as the old one.

* Extracts from INTERAVIA AIR LETTER, daily international news digest, in English, French and German. All rights reserved.

Dr. Marc Birkigt, founder and Chairman of the Société Hispano-Suiza (Suisse) S. A., died on March 15th, 1953, at the age of 75. After completing his studies in motor vehicle construction, he founded at the age of 26 the Hispano-Suiza company in Barcelona, the forerunner to Hispano-Suiza Bois-Colombes, Paris, Geneva and throughout the world. Having become interested in aircraft engines, Birkigt created the well-known 140 h.p. Hispano-Suiza engine in 1914 on behalf of the French Air Force, and later built a series of aircraft engines with powers of from 350 to 1,100 h.p. at Bois-Colombes.

U.S. armed forces cut civilian employees

● The U.S. Army, Navy and Air Force have been ordered by Defense Secretary Wilson to cut their civilian staffs by 39,346 by the end of May, as part of the United States Government's economy drive.

Security leakages on British jet engines ?

● United Press reports that the Society of British Aircraft Constructors has asked for a tightening up of security regulations to prevent disclosure in the foreign press of details of Britain's new jet and rocket engines. "Indiscretions" have been reported on the following engine types : a new powerful gas turbine engine reportedly under development by de Havilland ; two rocket engines, the de Havilland *Spectre* and the Armstrong-Siddeley *Screamer ;* the Rolls-Royce *Conway* by-pass engine.—According to a Reuter report from London, Labour M.P. George Wigg claims that modifications to jet power plant in Britain are known and utilized in Russia on an average of one month after their introduction on jet combat aircraft at home. He maintains that MiG-15s operating in Korea incorporate the latest British improvements, in spite of the fact that Britain has not supplied any jet power plants to Russia since 1947.

SERVICE AVIATION

Allied air bases in Germany

● The "biggest air base in Europe," now being built for the U.S. Air Force at Landstuhl-Ramstein, near Kaiserslautern, is to be the home station of the U.S. Air Force's 86th Fighter-Bomber Wing (equipped with Republic *Thunderjets*) and the headquarters of the 12th Air Force. In addition to hangars the base—the first construction stage of which has already been completed—will have about 500 buildings.

Near the village of Elmpt, north of Aachen, a new air base, named "Brüggen," is being built under British supervision. It is to be finished in July 1953, to cost DM 60,000,000 and have living accommodation (plus church) for 180 families. Initially destined for British jet aircraft units, Brüggen is expected in German aviation circles to be used later for the future German air force under the European Defence Community.

Airborne medical centre

● The 307th Airborne Medical Battalion of the U.S. Army's 82nd Airborne Division has developed a complete hospital unit capable of being dropped by parachute. The whole installation weighs only 47,000 lbs. and can be loaded on board 15 Fairchild C-119 *Packets* (including attached jeeps) within six hours. It can be set up on the ground in less than one hour and can care for 120 patients at once.

Operational altitude 65,000 ft.

● During NATO's "Exercise Jungle King" over Germany an English Electric *Canberra* flew at an altitude of over 65,000 ft.—A U.S. Navy McDonnell F2H-2P (reconnaissance version of the *Banshee* jet fighter) recently took pictures over the San Diego Bay (Calif.) area from an altitude of 54,650 ft. The surprisingly clear pictures showed the whole area from the Mexican border to the southwest edge of Los Angeles (200 miles).

Indochina airlift

● The French Secretary of State for Air is reported to be planning an airlift between France and Indochina, to be operated by Air France, Union Aéromaritime de Transport, Compagnie des Transports Aériens Intercontinentaux and Aigle Azur, using SE 2010 *Armagnacs.*

Dutch Air Force an independent service

● A special order of the day issued by Lieutenant-General I. A. Aler, Commander-in-Chief of the Netherlands Air Force, announced that the Air Force, which celebrates its 40th birthday on July 18th, 1953, has

The new terminal building at *Kloten Airport, Zurich,* was opened to the public on April 9th, 1953.

Flight *Lieutenant Doug Biden "blown up":* Jet pilots of the Royal Canadian Air Force will wear a nylon pressure suit for high altitude flights above 33,000 ft. and supersonic flights, as here demonstrated by Flight Lieutenant Biden at Monckton test centre, near Ottawa.

SNCA-SO 4050 Vautour with SNECMA-ATAR 101 C turbojets. The SO 4050 can be used as all-weather fighter, light bomber or ground attack aircraft.

been made into an independent service. At the same time Prince Bernhard, who holds the rank of Lieutenant-General, was appointed Inspector General of the new "Royal Netherlands Air Force."

AIR TRANSPORTATION

Tourist-class services

● In conformity with the decision taken by the International Air Transport Association in November 1952, IATA member airlines introduced tourist-class services on their European and Middle East network on April 1st, 1953, with reductions in fares of up to 20 to 30%.—Aerolinee Italiane Internazionali (Alitalia) too, although no longer a member of IATA, has included second-class services in its summer timetable, so as to be able to compete with Linee Aeree Italiane (LAI).

Meanwhile the controversy about the number of seats permissible in aircraft operating tourist-class services continues. United Air Lines' President W. A. Patterson sticks to his argument that 54 is the maximum number of passengers which he will undertake to carry in safety in the Douglas DC-4. On the other hand the Civil Aeronautics Board insists that UAL equip its tourist-class DC-4s for 66 passengers.—At the end of March the International Federation of Airline Pilots Associations entered the debate with a statement that present developments were leading to overcrowding in airliners and urged that all commercial transports be fitted with sufficient emergency doors to permit of rapid evacuation in the event of danger.

Sabena's helicopter services internationalized

● W. Deswarte, General Manager of the Belgian airline Sabena, told a press conference that his company had decided to buy three Sikorsky S-55 helicopters (which can carry seven passengers or one ton of freight). When these are delivered at the end of summer 1953 they will at first be used on the Brussels—Libramont—Liège—Tongre—Hassault—Beringen—Herenthals—Antwerp—Brussels mail circuit, hitherto operated by Bell 47-B-1s. Beginning in the spring of 1954 there will be services from Brussels to towns in the frontier regions of France, Holland, Germany and Luxemburg, such as Cologne, Rotterdam, Lille, Luxemburg, Saarbrücken, etc. Negotiations with the competent authorities in these countries have already been opened. Sabena's first helicopter terminal station is to be built near Brussels' Nord station.

INDUSTRY

Off-shore orders for Europe

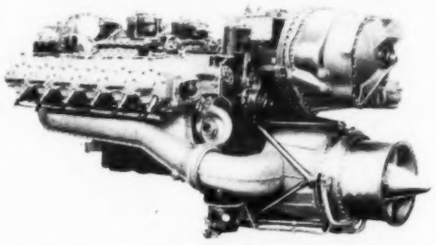
● The American authorities have now definitely decided to order Hawker *Hunter* jet fighters, instead of Supermarine *Swifts*, under the off-shore programme. The decision was based on a report by Al Boyd, well-known U.S. Air Force evaluation pilot, who considered the *Hunter's* performance superior.—Marcel Dassault's *Mystère IV* may also receive off-shore orders, with tooling perhaps being provided from American military aid.—As regards Italy, an agreement was signed at NATO's European air force headquarters on March 26th under which Officine di Pomigliano d'Arco per Costruzioni Aeronautiche will take over manufacture of parts for the Republic F-84 *Thunderjet*.

Hiller's 1952 profits

● Hiller Helicopters Inc.'s net profit for 1952 was $617,059, compared with $120,779 in 1951, a sign of the boom in helicopter business.

German aeronautical research again

● Aeronautical research is to be resumed in Western Germany with effect from the beginning of the 1953/54 budget year (April 1st, 1953). To begin with a number of research projects will be allocated to professors of technical universities. Funds available for the first year will be DM 3,500,000, of which DM 2,000,000 have been provided by the Deutsche Forschungsgemeinschaft.



Napier *Nomad N.Nm.6* compound engine of 3,150 eshp.

Sweden at the Paris Air Show

● For the first time since the war Sweden's aircraft industry is to take part in this year's Paris Air Show (June 26th to July 5th). Exhibits will be the Saab J 29 jet fighter and the Saab *Safir* trainer and communications aircraft.

AIRCRAFT

● The twin-engined SO 4050 *Vautour* (SNECMA-ATAR 101 C turbojets) is reported to have reached speeds of more than 680 m.p.h. in level flight at 6,560 ft. during its tests. This would make it the fastest and most promising aircraft of French design (it can be used as all-weather fighter, light bomber and ground attack aircraft). Particularly so, as the ATAR 101 C engines are later to be replaced by more powerful ATAR models.

● The North American F-86 D *Sabre* interceptor fighter fitted with General Electric J-47-GE-17 turbojet with afterburner is armed exclusively with *Mighty Mouse* rockets. Altogether 24 rockets are carried in retractable racks underneath the fuselage. The *Mighty Mouse* has a calibre of 2.75 in., is approx. 4 ft. long and weighs about 18 lbs. It has a powder propellant and folding fins.

● *Aeronca Aircraft Corp.* plans to enter the touring and executive aircraft market with a new twin-engined model. It is to have accommodation for 10 persons and be fitted with two 1,525 h.p. Wright R-1820 engines. The prototype is to be built in 1954.

POWER PLANT

● A Hispano Suiza *Tay* turbojet has been subjected to an official 150-hour test at Hispano's Bouvier plant corresponding to the British Type Test. Hispano Suiza has made a number of structural improvements in the *Tay*, which have given it higher performance (e.g. thrust increased from 6,260 lbs. to 6,830 lbs.).

● Test bed trials of an afterburner installation for the *SNECMA-ATAR 101 D* (dry static thrust 6,600 lbs.) are in progress. The ATAR 101 version with reheat has been designated 101 F. It is also to be tested in flight in a Gloster *Meteor*, *Languedoc 161* and Dassault MD 450 *Ouragan*.

● Certification tests of the SNECMA 14 X *Super Mars* 14-cylinder two-row radial engine have been completed at the Engine and Propeller Test Centre; the engine has been certificated for a take-off power of 850 CV.

● The *Potez 6D 30*, a version of the well-known 240 CV Potez 6 D engine, with supercharger and direct fuel injection, has been passed by Chalais-Meudon test centre under ICAO conditions. Permissible power 305 CV.

● A ramjet engine built by Arsenal de l'Aéronautique has been tested in Modane wind tunnel at rates of flow corresponding to Mach 0.85. Flight tests have also been made in a number of aircraft up to an altitude of 31,000 ft.

● D. Napier & Son Ltd. announces a development of the *Nomad* compound engine—the *Nomad N.Nm. 6*. Length 9 ft. 11 in.; frontal area 19.25 sq.ft.; dry weight 3,580 lbs.; take-off power 3,135 eshp.

ACCESSORIES

● The *Pioneer Parachute Co. Inc.*, Manchester, Conn., has acquired sales rights for a new personnel parachute designed by Dr. H. G. Heinrich, of Wright Air Development Center, Dayton, Ohio. Known as the Personnel Guide Surface Parachute, it is particularly suitable for high speeds and has greater stability in descent, lower rate of descent and reduced opening shock.

● The U.S. Naval Ordnance Laboratory has announced the development of a new aluminium alloy on the basis of preliminary Japanese work, to be known as "16 Alfenol." Qualities: great hardness, low weight, magnetic, good electrical conductivity. Use: aircraft equipment, in particular electronics.

● *Decca Radar Ltd.*, London—a branch of the Decca concern—reports development of the "Decca Radar Link" for the transmission of radar screen pictures without loss of clarity over distances of up to 20 miles (still greater distances can be covered with the aid of boosters). The new equipment can be used for both civil and military purposes to connect up radar instruments with distant control centres, for early warning radar, GCA landings, airport area control, airfield surface movement control, etc.

SFECMAS 1301, a single-seater delta-wing glider model used for experimental purposes by Société Française d'Etude et de Construction de Matériels Aéronautiques Spéciaux.

FLYING ROBOTS

Centre of Pressure Travel on a Supersonic Wing in the High Subsonic Range

by H. R. VOELLMY,

Guided Missile Development Division of Oerlikon Machine Tools Factory,

Bührle & Co., Zürich

Guided rockets need lift-producing wings, which must meet stringent requirements over the whole speed range. Aerodynamic behaviour in the high subsonic range can only be ascertained in part by theoretical calculations. The suitability of a given wing design can be confirmed only by measurements on models in wind tunnels and experiments in actual flight. Apart from the measurement of lift and drag, the utmost importance must be attributed to the accurate determination of the aerodynamic moments about the transverse axis (longitudinal stability), as these values have a decisive influence on the rocket's controllability and hence on its accuracy of pursuit.

Although the rocket body, generally long and slender, may exert certain normal forces and moments about the centre of gravity, these forces remain *small*, compared with those of the wings. The aerodynamicist will therefore pay greatest attention to the forces on the wing.

*

The following paragraphs describe how pressure distribution on a wing model is measured, with the primary object of ascertaining the position of the centre of pressure as a function of Mach number and angle of attack. The centre of pressure is defined as the point at which the air force component at right angles to the plane of the wing chord passes through this plane. As the rocket's centre of gravity lies in the plane of the wing chord, the other air force component in this plane does not affect the aerodynamic moment. *The distance of the centre of pressure from the centre of gravity of the rocket therefore provides a convenient criterion for judging stability.*

The wing investigated was of the symmetrical trapezoidal plan shown in *fig. 1*. The airfoil selected was of double wedge shape with a relative thickness of 5 %. Apart from its small leading edge radius, it is a typical supersonic airfoil of minimum drag. Measurements made in the high subsonic range are expected to demonstrate that it would also be useful below sonic speeds.

The measurements are made on models in the supersonic wind tunnel at the Aerodynamics Division of the Federal Institute of Technology (under Professor J. Ackeret). *Fig. 2* shows the wing used, which consists of two halves soldered together. Four airfoil sections have eight apertures each (on the same side) for measuring pressure, seven of which can be connected to the manometers at a time. The wing is held in position by a part of the rocket body fitted to a rotatable port in the side of the tunnel.

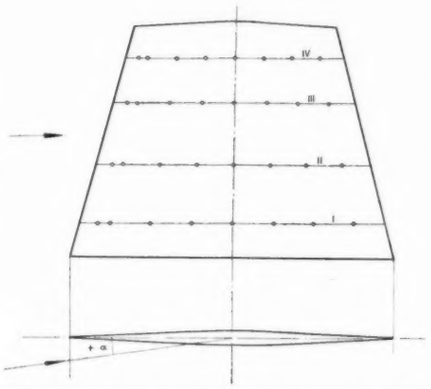


Fig. 1. Plan and airfoil of the trapezoidal wing used for measurements, showing apertures for pressure measurements (sections I to IV).

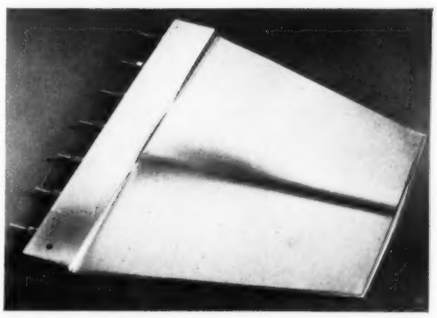


Fig. 2. Wing model with 32 measuring apertures.

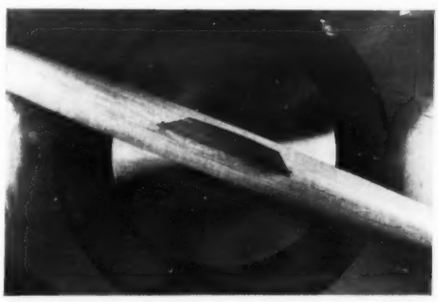


Fig. 3. Installation of wing model in the supersonic wind tunnel; it is held in position by a half model of the rocket body.

Fig. 3 gives an internal view of the tunnel's wall and the model. The port, under a pressure of about 400 kg, can be rotated by means of a simple mechanism. The experiments were carried out at all Mach numbers with a Reynolds number of 0.72×10^6 based on the mean wing chord.

Pressure distribution over the wing chord at Mach 0.4 is shown in *fig. 4* for all four wing sections, the angle of attack serving as curve parameter. As the airfoil is symmetrical, pressure distribution need only be measured on one side of the wing: pressures on the upper wing surface—with positive angle of attack—are equal to pressures on the lower surface with corresponding negative angle.

The first striking phenomenon is the similarity of the pressure distribution in all four sections, all of which are shown as having the same chord. The marked pressure variations with variations in angle of attack are characteristic of airfoils with small leading edge radius. Near the wing trailing edge on the other hand, pressure remains almost unaffected by variations in angle of attack up to angles of approx. 12°. As the angle of attack is still further increased, the area of suction spreads over the whole upper surface of the wing (break-away at the leading edge), and a marked change in the resultant force might be expected. However, integration shows that forces increase very steadily with angle of attack, but that on the other hand moments show powerful divergences from the linear pattern.

The similarity between the pressure distributions in the four sections persists even with increasing Mach numbers. Behaviour from now on will therefore be shown for section II only *(fig. 5)*.

At Mach 0.7 a local supersonic area appears, for the first time, at the leading edge at angles of attack of over 4°, a consequence of the sharp leading edge. *The pressure range for supersonic flow is shown in grey in the diagrams.*

As Mach number rises the local supersonic area originating at the leading edge spreads, marked negative pressures at the leading edge already set in at small angles of attack, and at Mach 0.85 there is a supersonic area at the largest airfoil thickness even at an angle of attack of zero. Beyond this critical Mach number there are three local supersonic zones at small angles of attack, bounded downstream by compression waves. Two of them are on the upper surface of the wing, the third on the lower.

Schlieren photographs of a small rocket model with four cruciform wings of this design show clearly the two compression waves on top of the wing at Mach 0.92. The reader is referred here to *fig. 6*, in which, however, the wings are inclined at an angle of 45° to the plane of the picture.

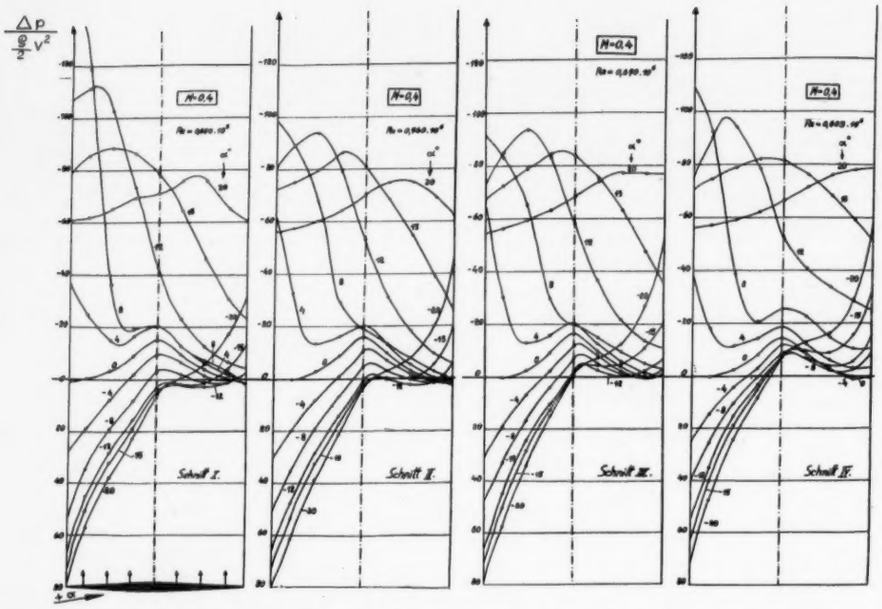


Fig. 4. Pressure distribution over the wing chord for sections I to IV at Mach 0.4 and angles of attack of —20° to +20°. Δp is given as a percentage of 1/2 ρv².

A three-dimensional view of pressure distribution on the upper surface of the wing *(fig. 7)* displays the rapid growth of the negative pressure peaks with increasing Mach number.

Integration of the pressure distributions, with the object of determining the normal forces and moments, produces, surprisingly enough, a considerably calmer picture. Distribution of the normal forces over the wing span is entered in *fig. 8* for Mach 0.8. As the very similar pressure distributions in the four sections had already suggested, the distribution shows a similar form to the wing plan, and lies roughly between an elliptical and a trapezoidal pattern. This characteristic persists throughout the whole Mach range investigated.

Because of the similarity of pressure distribution in neighbouring sections, section II was chosen as a basis for detailed measurements. The conclusions presented below all refer to these measurements, and the local coefficients can be applied to the whole wing.

Fig. 9 shows the very smooth behaviour of the normal force versus the geometrical angle of attack for the Mach numbers measured. Because of the wing's low aspect ratio, the normal force curves entered versus the geometrical angle of attack have small values.

In *fig. 10*, the normal force gradient is entered against the Mach number (curve a). The apparently small compressibility effect becomes considerably larger when the normal force gradient is converted for the effective angle of attack (curve b). Curve b, however, does not reach the pattern extrapolated

Fig. 6. Schlieren photograph at Mach 0.92: compression waves on the wing of a small wind tunnel model with cruciform wings of the type discussed here. The wings are at an angle of 45° to the plane of the photograph.

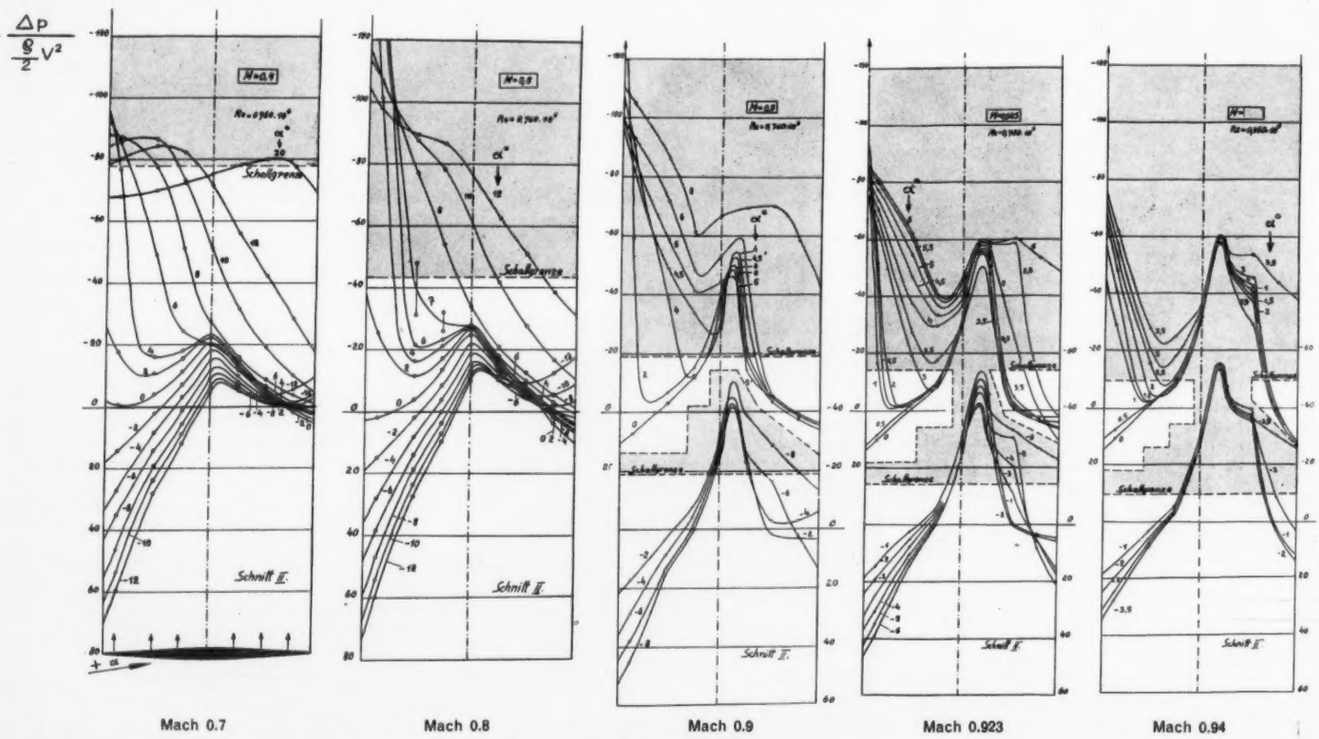


Fig. 5. Pressure distribution for section II with increasing Mach number. The pressure range for local supersonic flow is shown in grey. Δp is given as a percentage of 1/2 ρv².

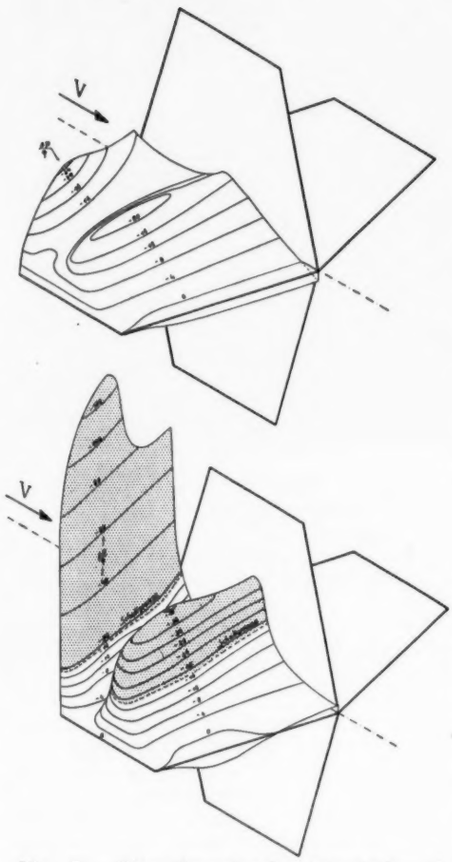


Fig. 7. Three-dimensional representation of pressure distribution on the wing's upper surface at Mach 0.7 and Mach 0.9 for an angle of attack of 2°.

from the converted point for Mach 0.4 by Prandtl's rule (curve c).

Fig. 11 shows the behaviour of the moments about a reference point at 25 % of the chord as a function of the geometrical angle of attack. Here, for the first time, pressure distributions, which vary considerably with angle of attack and Mach number, have a marked effect. Whereas at small angles of attack the wing moment—especially at Mach numbers in the critical range—is very unstable, this instability gives place at increasing angles of attack to an extremely great stability, a result of the break-away of the flow at the sharp leading edge.

The same marked variations are reflected in the movement of the centre of pressure shown in *fig. 12.* Once again we are struck by the abruptness with which the position of the resultant air force in the critical Mach range varies as a function of the Mach number. At small angles of attack the air force first shifts forwards as Mach number increases, whereas at larger angles it moves backwards with increasing Mach number.

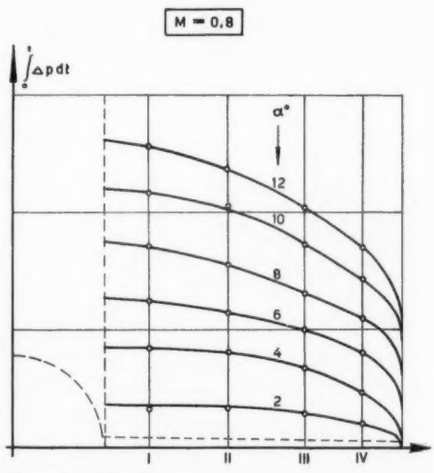


Fig. 8. Distribution of normal force over the span for Mach 0.8.

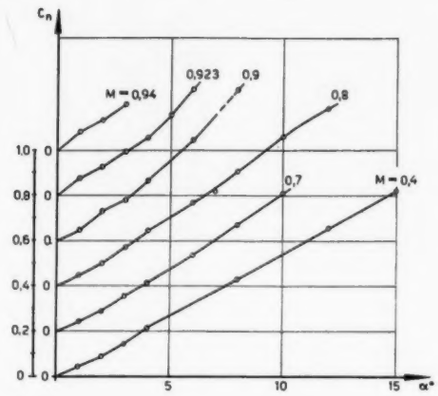


Fig. 9. Normal force pattern C_n for section II as a function of angle of attack α and Mach number M.

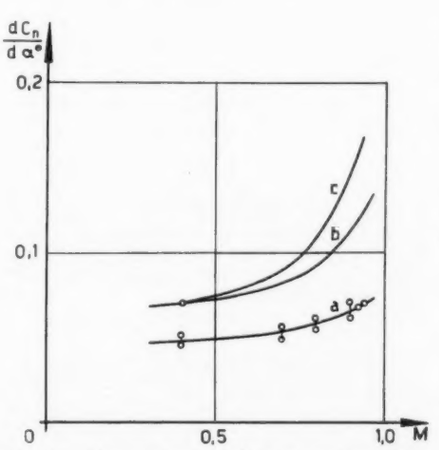


Fig. 10. Normal force gradient for section II in relation to the geometrical (curve a) and effective angle of attack (curve b) plotted against Mach number. Curve c shows the extrapolation according to Prandtl's rule through the point for Mach 0.4.

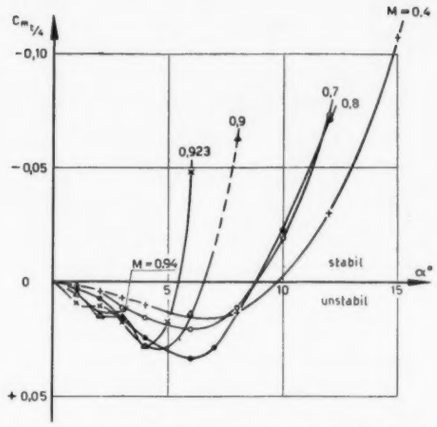


Fig. 11. Moment behaviour for section II plotted against angle of attack α and Mach number M.

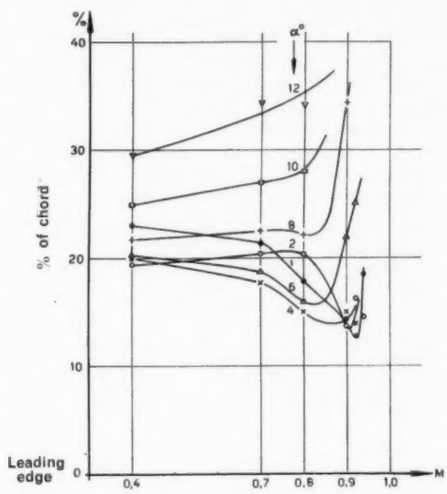


Fig. 12. C.p. position for section II plotted against Mach number and angle of attack.

In the supersonic range the centre of pressure of this symmetrical airfoil lies at slightly less than half the wing chord. *In the narrow range between the critical Mach number and the supersonic zone the centre of pressure must therefore cover a path corresponding to nearly 40 % of the wing chord.*

This is the deciding factor in any consideration of whether the wing, primarily designed for supersonic flight, is also suitable for use in the subsonic range.

*

To sum up, the supersonic wing with its typical supersonic airfoil, under consideration here, may be termed satisfactory in the high subsonic range as regards the production of normal force, but the sudden variations in stability occuring when the critical Mach number is exceeded or the angle of attack increased may give rise to difficulties if the wing is used as main lifting surface.

FLYING ROBOTS

The Chance Vought Regulus

At the end of March 1953 the U.S. Department of Defense announced the existence of a new guided missile, the *Regulus*, designed for launching from submarines, surface ships and shore bases. It has been developed by the *Chance Vought Aircraft Division* of United Aircraft Corporation under the sponsorship of the *Navy Bureau of Aeronautics*.

The Navy now feels that the program, started in 1947, has reached the stage where information concerning some of its earlier phases can be released.

Externally, the *Regulus* resembles a conventional swept-wing jet fighter. It is about 30 feet in length and is built in several versions, in particular as :

— Experimental model ;
— Trainer and target aircraft ;
— Combat aircraft.

The first two versions are fitted with a nose-wheel undercarriage so that the missile can be recovered on completion of its flight. Pilotless experimental missiles are initially almost as costly as normal jet fighters, so that their recovery makes for considerable economies. Flight testing takes about a hundred flying hours, and this would have needed about 200 missiles if each had been expended, whereas in practice only 30 recoverable weapons were used. The Navy states that as many as 10 flights were made with a single model. Landings are made with the aid of a parachute brake on a normal size runway.

The tactical missile on the other hand has no undercarriage but carries a powerful warhead. It will be used against appropriate land targets and in amphibious warfare by the U.S. Marine Corps and the Navy. Launching is by catapult, the jet engine being assisted by two powerful take-off rockets. Launching equipment can be installed in a short period of time on several types of vessels, including submarines.

Testing of the *Regulus* began in 1950 at Edwards Air Force Base, California. The machine was then sent to the Navy's *Air Missile Test Center* at Point Mugu, California, for over-water testing. Finally, the Navy equipped the U.S. submarine *Tunny*, a veteran of World War II, with a water-tight tank for the robot and with launching equipment. The submarine was also streamlined and fitted with a snorkel for under-water operations. A group of officers and men from the *Tunny* spent several months at Point Mugu last year, to learn how to handle and service the *Regulus*.

The Navy's service plans envisage wide use of the *Regulus*, both as tactical weapon and as recoverable test machine. The recoverable version is being used to train operating units in launching and guidance technique. It can also be used as a high speed drone for anti-aircraft guided missiles and anti-aircraft artillery.

Having completed the first phase of its operational tests, the *Regulus* is now in production at Chance Vought's Dallas, Texas, plant. The results obtained greatly exceeded early design specifications, and several of the experimental versions have even reached supersonic speeds on a number of occasions.

Materials for Rocket Combustion Chambers

by H.G. MEBUS, Bettenried, nr. Sonthofen

Rocket combustion chambers are subjected to such tremendous thermal stresses, because of the high temperatures and high speed of the combustion gases, that it is extremely difficult to give them a reasonable life.

Rocket engines that are to run for more than a few seconds must use liquid propellants. The walls of the combustion chamber are then cooled from outside by the propellant—normally the oxidiser, the component present in larger quantities, which is passed round the combustion chamber at high speed before injection.

The materials required for combustion walls must have a *high* melting point on the one hand, and *good thermal conductivity* on the other. Unfortunately most of the possible materials with a high melting point also have relatively poor conductivity, and vice versa.

The number of suitable materials is further reduced by the necessity of their being *resistant to corrosion by oxidizers and combustion gases*. Copper in particular has to be completely eliminated for this reason.

On the other hand *aluminium and high-grade steel*, and a number of other much more costly metals, such as *tantalum and tungsten*, are highly suitable.

*

Before comparing the most promising materials, the operating conditions obtainable in practice should be examined. This is done below for the normal propellant combinations based on nitric acid. The net heating value H_u for such combinations is 1,300 Kcal/kg and, with the combustion efficiencies ν of about 83% obtained today, gives *combustion temperatures* T_0 of *2,500°C or 2,773° Kelvin.*[1]

Combustion efficiency ν *is found from measurements of the specific propellant consumption*, which, for the usual ratio of expansion (combustion chamber pressure $p_0 = 25$ kg/cm², outside pressure $p_a = 1$ kg/cm²), is about $\kappa = 4.9 \times 10^{-3}$ kg/kg.sec on an average.[2]

Combustion chamber pressures of up to $p_0 = 40$ *kg/cm²* are acceptable, at the above-

[1] If the ratio of specific heats κ is taken as 1.22 and gas constant R as 30 m/°C, combustion temperature will be :—

$$T_0 = \nu \frac{\kappa - 1}{\kappa} \frac{H_u}{R \cdot A} = 0.83 \frac{0.22}{1.22} \frac{1300 \times 427}{30} = 2770^{\circ} K$$

[2] Using the above values we get :—

$$\nu = \frac{g \cdot A}{2 k^2 \cdot H_u} \cdot \frac{1}{1 - \left[\frac{p_a}{p_0}\right]^{\frac{\kappa-1}{\kappa}}} = \frac{9.81}{2 \times 4{,}9^2 \times 10^{-6} \times 1300 \times 427} \cdot \frac{1}{\left[1 - \frac{1}{25}\right]^{\frac{0.22}{1.22}}} = 0.83$$

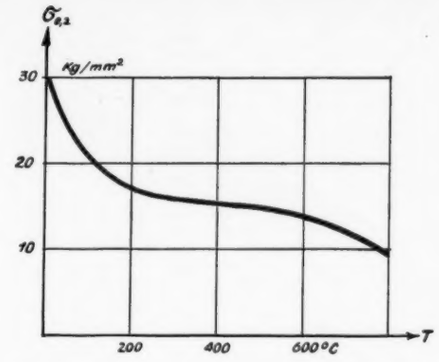


Fig. 1. Yield point $\sigma_{0,2}$ (in kg/mm²) of high-grade steel V2A plotted against temperature (in °C).

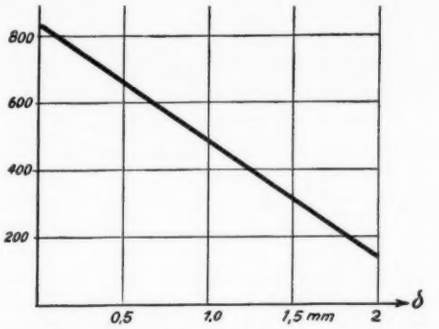


Fig. 2. Temperatures in combustion chamber wall of high-grade steel.

mentioned combustion temperature, in long-period operation. Here coolant speeds (i.e. of the oxidizer) of at least 19 m/sec are required for the particularly sensitive throat section of the propulsion nozzle.

The thermal stresses in the most important materials given in the table below apply to a combustion chamber with a thrust of 1,000 kg, a jet throat factor of 0.94 and a throat section of 17.6 cm².

For a coolant speed of 19 m/sec a cooling space of 0.8 mm is required.

Wall temperatures—inside T_1 and outside T_2—are calculated from combustion temperature T_i and coolant temperature T_a with the heat flow passing through the combustion chamber wall in stationary condition, as follows :

$$T_1 = T_i - \frac{T_i - T_a}{1 + \alpha_i\left(\frac{1}{\alpha_a} + \frac{\delta}{\lambda}\right)}$$

$$T_2 = T_a + \frac{T_i - T_a}{1 + \alpha_a\left(\frac{1}{\alpha_i} + \frac{\delta}{\lambda}\right)}$$

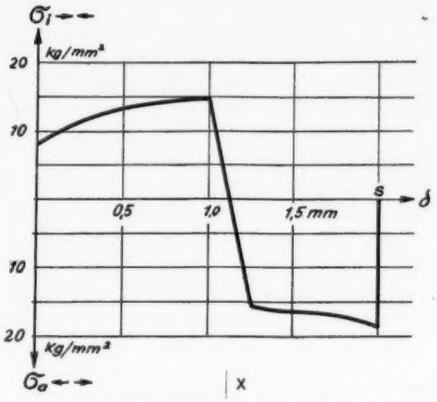


Fig. 3. Residual temperature tensions in the combustion chamber wall during operation.

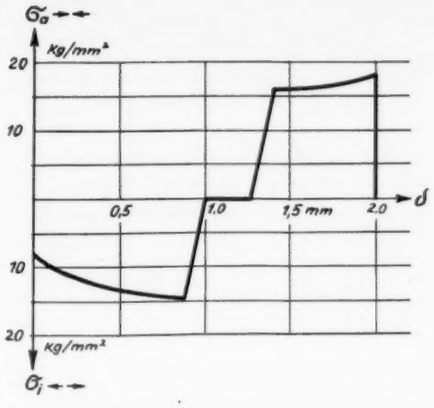


Fig. 4. Residual tensions in the combustion chamber wall after cooling down.

Here α is the heat transfer figure and S the wall thickness (2 mm). In the throat section the combustion temperature has already fallen to T_i=2500°K, owing to partial expansion. In the given conditions, the heat transfer figures are d_i=0.91 kcal/m² sec °C on the combustion side and α_a=11.6 kcal/m² sec °C on the coolant side.

The table shows not only melting points of the various materials but also their thermal conductivities λ and inside wall temperatures T_1. The differences between wall temperature and melting point and the ratio of the two values, and finally the temperature gradient in the combustion chamber walls are also given.

All these values can be regarded as *indices* of the suitability of various materials for use in rocket combustion chambers. The best materials are found to be those in which wall temperature is furthest from melting point, ratio of wall temperature to melting point is small and temperature gradient in the wall is also as small as possible.

Tungsten and tantalum are therefore the most suitable. These are followed, some way behind, by the other materials. Among them aluminium, with its good heat conductivity, has the smallest temperature gradient in the walls, whereas titanium and high-grade steel have the advantage of very much higher melting points. *In practice, aluminium and high-grade steel have been found to be equally good, though the latter is more robust.*

Experience of *titanium* is still limited. A disadvantage is its sensitivity at high temperatures to corrosion by oxygen and nitrogen, which are contained in the combustion gases.

High temperature gradients in the combustion chamber walls produce pressure stresses inside and tensile stresses outside because of *expansions*. These stresses are generally well above the yield point and leave residual tensions acting in the opposite direction after cooling.

This phenomenon may be illustrated by the *example of a combustion chamber wall of high-grade steel (V2A)*. Yield points and temperatures are shown in *figs. 1 and 2*. *Fig. 3* shows the tensions in the wall after warming up during the first run by the combustion chamber, *fig. 4* the residual tension after cooling down. In both diagrams it is assumed that the combustion chamber can expand without hindrance and that the material is plastically deformed when warm by the stresses beyond the yield point to such an extent that the overall tension returns to the stress corresponding to the yield point.

The longitudinal expansion of the combustion chamber wall caused by heating does *not* correspond to the temperature expansion at the arithmetical mean of the two wall temperatures. As position × of the tension-free axis in fig. 3 shows, it corresponds to a somewhat lower temperature. The position of this tension-free axis can be calculated from the balance of forces,[3] the solution however, only being an approximate one, since the temperature tension condition [3] no longer applies after the yield point has been passed.

Finally, temperature tensions are overlaid by *mechanical stresses in the wall*, caused by the coolant pressure from outside and the pressure of the combustion gases from inside. Tensions exist along three axes. In general the mechanical stresses set off a further displacement of the neutral zone outwards.

In a closer investigation of stresses, allowance would always have to be made for structural characteristics. For example, important points are the manner in which the combustion chamber wall is connected to the outer jacket and how rigid this connection is.

THERMAL STRESSES IN A NUMBER OF MATERIALS

in a combustion chamber for 1,000 kg. thrust and 40 kg/cm² pressures, cooled by the oxidizer

Propellant combination based on nitric acid Wall thickness 2 mm.

Material	Melting Point	Heat Conductivity	Inner Wall temp.	$T_s - T_1$	$\frac{T_1}{T_s}$	Temp. gradient in wall
	T_s [°K]	λ $\left[\frac{k\ cal}{m\ sec\ °C}\right]$	T_1 [°K]	[°C]	$\left[\frac{°K}{°K}\right]$	[°C/mm]
Aluminium	931	0.0550	520	411	0.559	31
V2A Steel	1,673	0.0036	1,110	563	0.664	349
Titanium	2,000	0.0036	1,110	890	0.554	349
Tantalum	3,303	0.0130	700	2,603	0.212	128
Tungsten	3,653	0.0400	540	3,113	0.148	42

[3] The corresponding equations are :

$$\int_{\delta=o}^{\delta=x} \sigma_i \cdot d\delta = \int_{\delta=x}^{\delta=s} \delta_a \cdot d\delta \quad or \quad \sigma = E \cdot \beta \cdot \Delta T$$

For V2A steel the elasticity modulus E = 19,500 kg/mm² and the coefficient of expansion is β = 17.5 × 10⁻⁶ per °C

FLYING ROBOTS

Induction Generators for Guided Missiles

By Elvin D. LYTLE,

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Induction generators are not new. They have been described briefly in various publications for more than fifty years. However, it is only within the last three years that they have been applied successfully as an aircraft electrical power source. In particular, the induction generator is unusually well adapted to serve as a power source for guided missiles.

The mechanical construction of an induction generator is similar to that of the standard polyphase squirrel cage induction motor. The detailed mechanical design is, of course, varied to suit the particular application and environment.

Principles of Operation

Most electrical engineers understand that an induction motor connected to an electrical system will generate power if driven faster than its synchronous speed. A considerable number of standard induction motors are being used as generators at the present time, by industry and public utility companies.

The electrical system is used to furnish the field excitation for the generators. The field excitation current drawn from the power line lags the voltage by 90 degrees, and is known as a reactive or wattless current. On the other hand, a capacitor draws a current which leads the voltage by 90 degrees, and when it is connected across the induction generator terminals, it cancels out all or part of the lagging generator excitation current.

When the capacitor has exactly the correct capacity, the excitation current drawn from the line is zero and the line can, therefore, be disconnected without affecting the generator operation. In this condition, the capacitive reactance of the capacitor and the magnetizing reactance of the generator become equal. They must always be equal during any steady state condition. On the other hand, when the excitation capacitor has more than this critical capacity, the generated voltage rises.

If the magnetizing reactance of the generators were constant, the generated voltage would continue to rise to an infinite value. However, since the iron in the generator magnetic circuit eventually saturates the magnetizing reactance it decreases until it is again equal to the capacitive reactance of the capacitor. Therefore, the generated voltage adjusts itself automatically until the two reactances become equal. After the generator becomes saturated, a large increase in capacity results in but a small increase in output voltage.

When a resistive load is applied to the generator, additional excitation current is required to compensate for the magnetic flux leakages within the machine. This current is deducted from that previously furnished by the capacitors to excite the generator and results in a voltage decrease. However, when the generator is operated in a highly saturated condition, the voltage drop is quite small.

This explanation of induction generator operation assumes that the machine is connected to an external electrical system in order to start the voltage build-up process. Such a connection is not necessary, however, if certain conditions are fulfilled. First, the build-up process requires that there be a certain amount of residual magnetism in the rotor ; and second, that the capacitive reactance of the capacitors be less than the inductive reactance of the generator.

At one time it was thought necessary to magnetize the rotor either by running the generator as a motor or by applying a small d-c voltage to the stator windings. Later, tests on several hundred generators have shown that sufficient residual magnetism is picked up during the various manufacturing operations to insure build-up under no-load conditions. The maximum load that may be applied to the generator during build-up will depend upon the size of the capacitors, and on the load that was connected to the generator when it was stopped during the previous run. Ordinarily, a typical generator will build up with full load connected. However, if it is necessary to supply a large incandescent lamp or vacuum tube filament load with their low cold resistance, it may be advisable to install an under-voltage relay between the generator and the load in order to insure certain build-up.

Design Factors

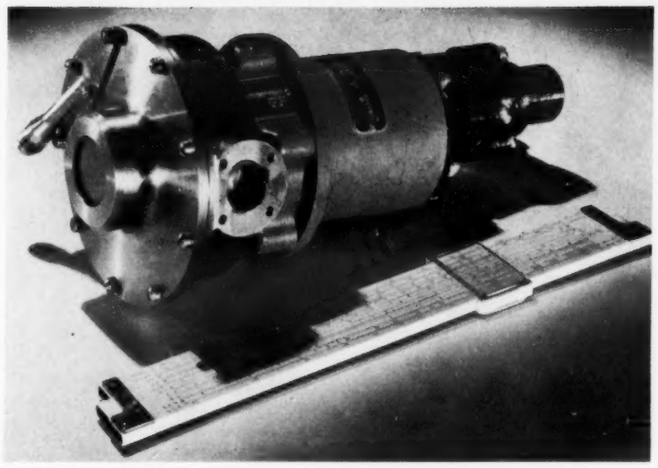
The electrical design of a good induction generator is considerably different from that of an induction motor. For this reason, tests run previously using capacitive excitation on standard induction motors have indicated poor performance, and have no doubt discouraged further development of induction generators.

Since the design of any electrical machine is a compromise of several performance requirements, a motor which is designed to give high efficiency, high power factor, and high starting torque, will not have good voltage and frequency regulation as a generator.

By designing an induction generator with voltage and frequency regulation as the most important requirements, a practical generator for guided missile use has been achieved. It has been found practical to obtain an inherent voltage regulation of from 3.5 to 7 per cent and a frequency regulation of from 0.5 to 1.25 per cent, depending upon the size and design of the machine. The lower values of voltage regulation are obtained at the expense of extra size and weight of both the generator and capacitor bank.

Most of the induction generators built to date have been designed to generate 115/200 volts, 3-phase, 400-cycle power. This system has been selected not only because it is aircraft standard, but because it results in an optimum design. The minimum practical voltage is determined by the size and weight of the excitation capacitors ; and the maximum voltage by the generator insulation (and possibly the size of the capacitor terminal insulator bushings). Voltages between 200 and 400 volts seem to be optimum for small-size machines. The minimum frequency is determined by both generator and capacitor size, and the maximum frequency by generator heating.

Since high flux densities are necessary for good voltage regulation, and the iron losses increase with the frequency, a point is reached where it becomes impossible to dissipate the heat, or even absorb it, for more than a short period of time. With thin-gauge high quality



AiResearch induction generator; 115/200 Volt 400 cycle a. c. current; 12,120 r. p. m.

lamination material, it is possible to obtain continuous duty operation at 400 cycles with relatively simple cooling systems. Intermittent duty operation is obtainable at 400 cycles with medium gauge material, and as high as 800 or 1000 cycles with thin gauge steel. Higher frequencies may require excessively complicated cooling systems.

Both 4-pole, 12,000 rpm and 6-pole, 8,000 rpm generators have been built and tested ; while 2-pole, 24,000 rpm machines appear to be practical. The 4-pole designs are preferred unless they are incom patible with prime mover considerations. The weights of 2-pole and 4-pole machines of a given rating will be about the same, although the 2-pole machine will be slightly more expensive to build. A 6-pole generator will weigh about 50 per cent more than an equivalent 4-pole machine.

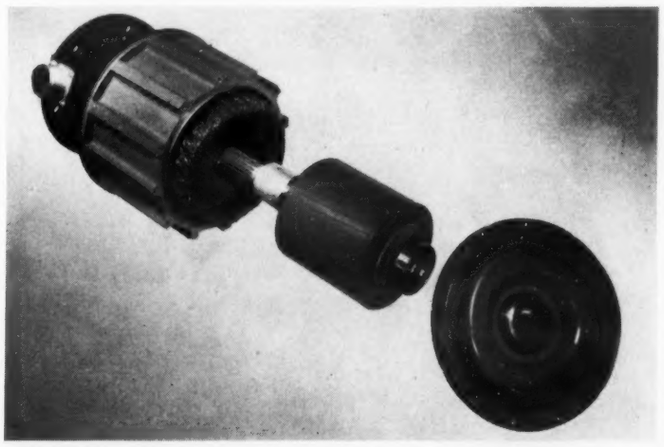
Installation Problems

Successful installation of an induction generator in a guided missile requires a suitable prime mover and speed control which will drive the generator at constant speed.

To insure a minimum of voltage unbalance, the missile electrical oad should be divided fairly equally among the three phases of the generator. The power factor of the electrical system should be determined accurately so that the correct rating of capacitors can be specified.

Provision for operating other auxiliaries such as cooling fans, hydraulic pumps or flywheels, when the prime mover is inoperative, can sometimes be accomplished by using the generator as an induction motor supplied by an external power supply.

Inside of induction generator ; robust constructton.



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The induction generator enjoys several important advantages over other generator types. The induction generator :

1. Is the simplest and most rugged of all types. It contains no rotating windings, magnets, brushes, slip rings, commutators or d-c exciters.

2. Does not require the use of complicated voltage regulations, carbon piles, rectifiers, stabilizing transformers, magnetic amplifiers, rheostats or electronic tubes. The only auxiliary equipment is a simple capacitor.

3. Has excellent inherent voltage regulation. There is no voltage overshoot or undershoot during load changes. The voltage changes smoothly to its new steady state value, and the machine maintains good voltage balance even under heavily unbalanced loads.

4. Does not generate radio noise, since it contains no brushes, slip rings or voltage regulating devices.

5. Will not be damaged by overloads or short circuits. Normal operation is restored immediately upon removal of the overload condition.

6. Can be designed for high operating speeds to permit direct turbine drive.

7. Has excellent wave form, since it contains no salient field poles. Any high order harmonics that may be generated are filtered out by the excitation capacitors.

8. May utilize large hollow rotor shafts to reduce rotor weight and bearing loads, as well as to provide extreme rigidity ; all of which are essential under high G loadings.

9. Contains no critical materials such as nickel or cobalt—an important consideration during wartime.

10. May be operated as an induction motor from an external power source prior to firing of the missile. During this time it can drive hydraulic pumps, air conditioning fans, energy storage flywheels, other generators and, in some cases, the prime mover. This motoring action also makes possible an extremely smooth transition from external to internal power, without power interruption or excessive voltage transients. Over-running clutches can be provided where it is not practical to drive the prime mover.

Conclusion

AiResearch has long been active in nine different and basic accessory fields, and the cooperation of these various engineering groups has produced some interesting results. An example of this coordination is the application of an AiResearch induction generator to the company's development of an auxiliary power supply for use in a guided missile. The overall design was aimed at producing a unit composed of a turbine of reasonable efficiency ; an induction generator of 12,120 rpm, 115/200 volts, 400 cycles, 3-phase; and a hydraulic pump to supply pressure at 3000 psi.

Although induction generators represent a relatively new field, their application to guided missiles has already been well established. The inherent stability and specialized characteristics of the same machine make it an attractive power source for piloted aircraft.

Silencing Jet Engine Test Houses

A CORRECTION

by "BOFFIN", London

In the article under the above title which appeared on pages 504-5 of the September issue of Interavia Review, I dealt briefly with the characteristics of the two basic types of silencer used for test houses, namely detuners and splitters.

In dealing with detuners it was stated that they do not cool the gases ; that there is considerable residual noise ; that a good result would be of the order of 87 phons at a distance of 100 yards, but with the major part of the sound within the human voice range ; and that it is wise to point the detuner towards uninhabited country as there is likely to be sufficient residual noise to cause annoyance at half a mile.

These statements, although based upon published information, did not fairly state the performance of the latest designs. In particular, tests conducted by the National Physical Laboratory, Teddington, England, on the Mark V installation designed and built by Detuners Ltd. are now available and reveal an entirely different picture, as follows :

In particular :

(I) The Mark V detuner does in fact cool the gases, the amount of cooling being pre-determined and chosen specifically to give the best results ;

(II) The Mark V detuner is over 20 phons quieter than the figure of 87 phons referred to in the article ;

(III) In the frequency range which governs intelligibility of speech, the noise from a large jet engine at top speed is reduced by the Mark V detuner to a level of less than 40 decibels at the same distance of 100 yards ;

(IV) The Mark V Detuner renders it unnecessary to raise the voice above normal speaking level even when close to the end of the detuner ;

(V) On the loudness scale a level of 61 phons is achieved by the Mark V detuner with a Ghost engine running at approximately 10,000 r.p.m. at a distance of 100 yards. As this is considerably quieter than the level of sound in the average street, there is no question of the residual noise causing annoyance at half a mile, or of the need for pointing the detuner toward uninhabited country. In fact Test Beds silenced by detuners may be sited among other engineering workshops, etc. without causing any disturbance whatsoever.

I am sorry if the remarks in my previous article could have been interpreted as referring to, or in any way reflecting upon, the Mark V detuner, designed and manufactured by Detuners Ltd. of Flower Mews, London, N. 19 which firm I understand is now the sole manufacturer of detuners.

In particular I hope that this correcting notice will make it clear to the readers of Interavia Review that the performance of the Mark V and later type detuners is of a far higher order than that which I ascribed to detuners and that Detuners Ltd. and the publishers of " Interavia " will accept this correction in the spirit in which it is offered.

BOFFIN, London

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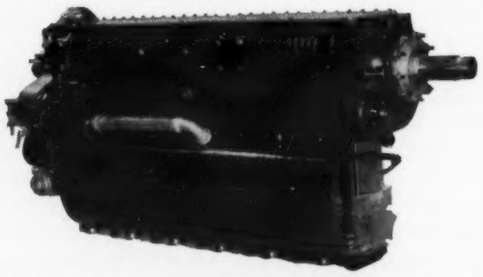

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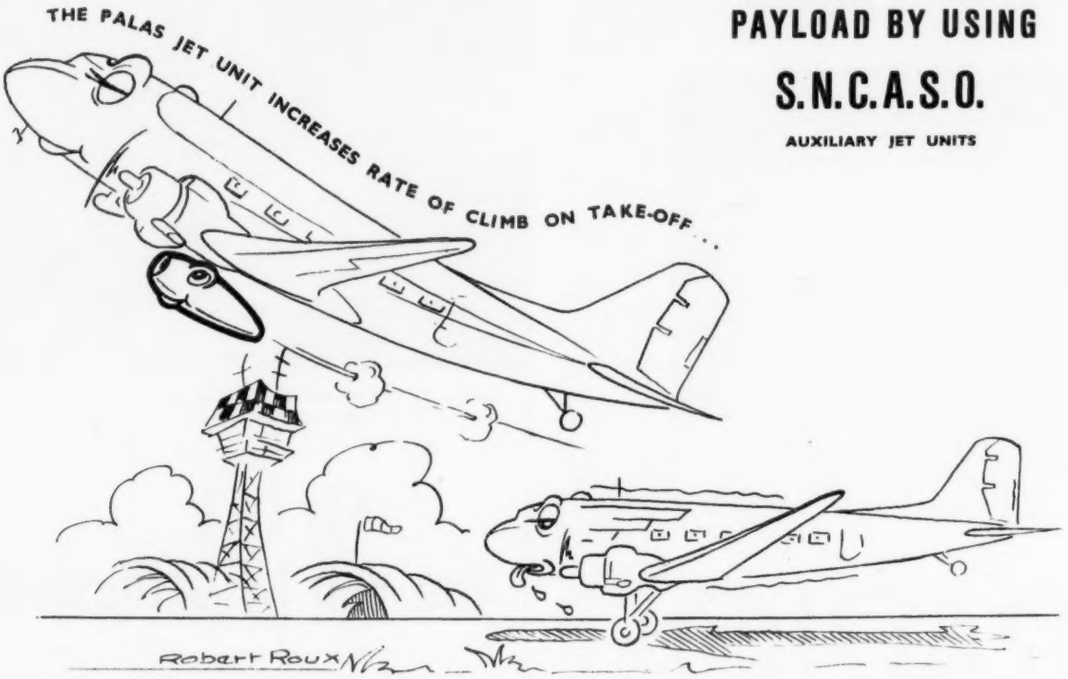

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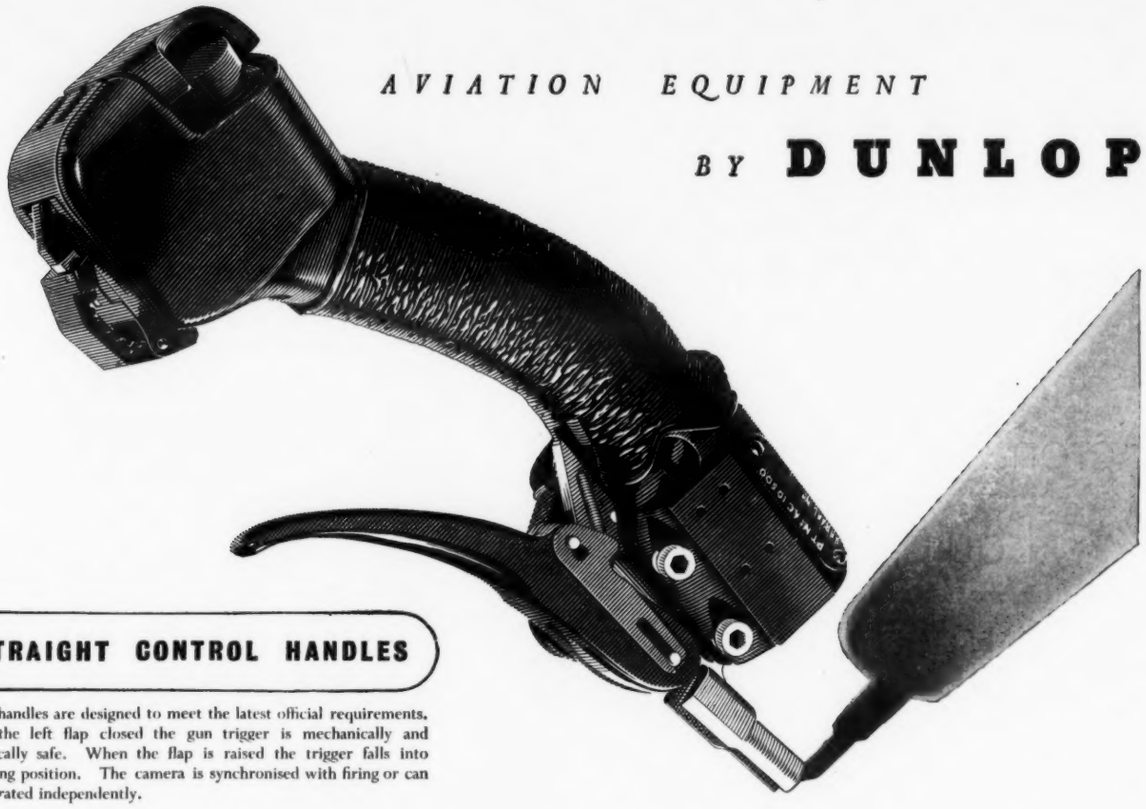

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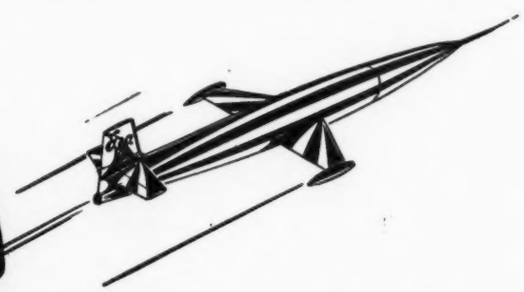

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